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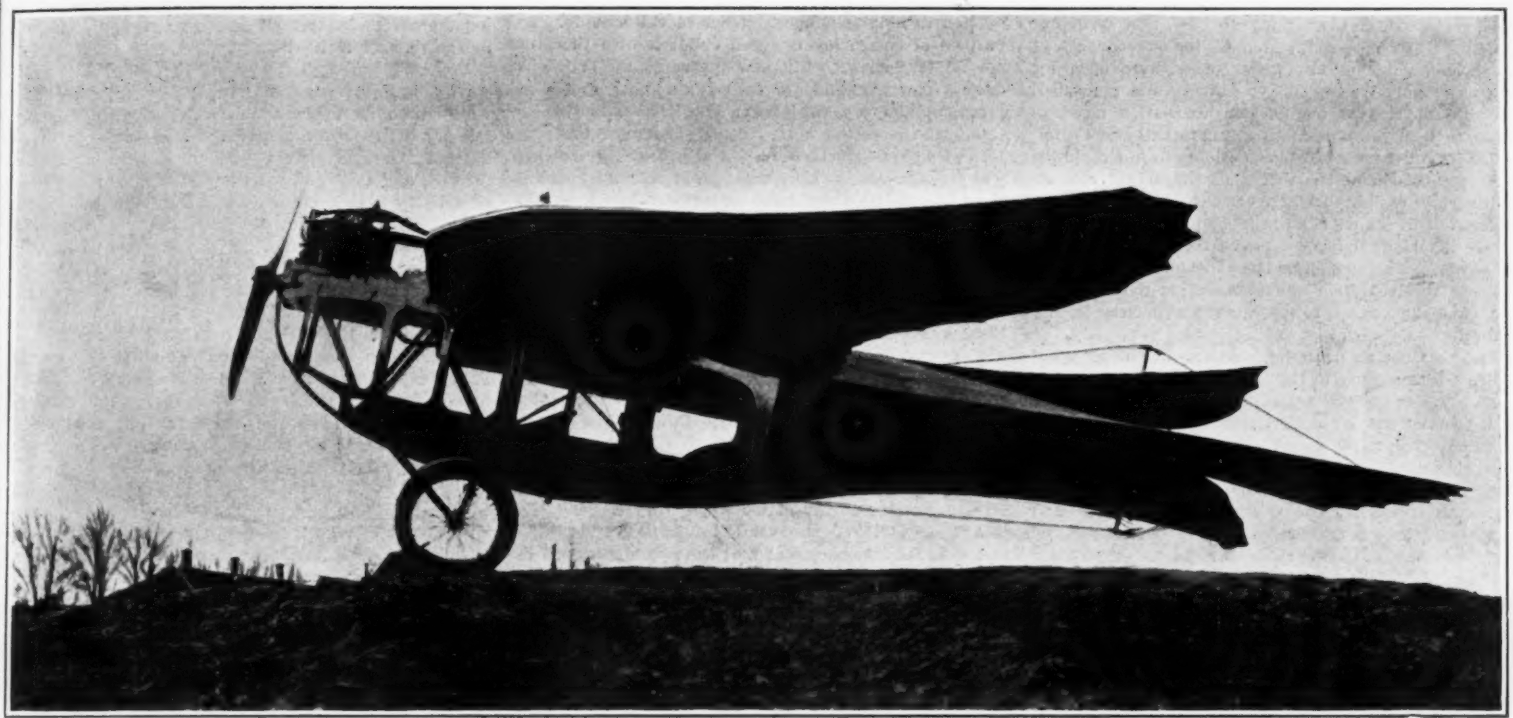


By Courtesy of *Aeronautics.*

The Etrich "Limousine"—the Latest Type of Austrian Monoplane.

The four inclosed seats, arranged in pairs, can be seen in profile through the celluloid windows.

By courtesy of the *Sphere.*

Three-quarter Rear View of the Military "Pigeon" Type, Seen from Above.

This picture gives a good idea of the relative positions of motor, passenger and pilot. It also shows the bird-like wings and their guy-rope bracing.

TWO OF THE LATEST ETRICH MONOPLANES.—**[See page 44.]**

American Association for the Advancement of Science

Third Cleveland Meeting, December 30th to January 4th

By William H. Hale, Ph.D.

CLEVELAND, sixth city of the United States, after twenty-five years again welcomes the American Association for the Advancement of Science. The first Cleveland meeting was held in 1853, the second in 1887. A few of those who attended the first meeting still survive; one of these Col. Edward Daniels, who read a paper here then, I met in 1887, and spent one delightful afternoon with him, calling successively at six hospitable mansions, whose doors were open for our reception. Was it here, I cannot quite remember, certainly it was at one of our association meetings away back in the nineteenth century that I met Prof. Woodrow of South Carolina, who even then glowed with enthusiasm at the recital of the ability and acquirements of his bright young nephew, Woodrow Wilson? But the dear old gentleman could not survive to see his idolized nephew sitting in the highest seat of power. But that illustrious nephew, as a letter which I received from him even during the ardors of the campaign, fully reciprocates his uncle's loyalty and affection.

And was not this meeting also one of the many of which I sent a story to the SCIENTIFIC AMERICAN?

The growth of our association during this quarter of a century has far outstripped that of the country: from less than 2,000 to more than 7,000 members, and now clustering about it nearly thirty affiliated societies. With the mass of material poured out by this numerous collection, one can only get glimpses and suggestions here and there, leaving of necessity many important matters untouched—just as we often hear that one half of New York doesn't know how the other half lives.

But the touch is inspirational and uplifting. One of the speakers at the opening session quoted a statement of a member that these meetings imparted to him such an inspiration that he could do more work in the six weeks following this meeting than he otherwise accomplished in a whole term. And the work of this association stands out in bold relief compared with that of many others in that it is the advance rather that the diffusion of science. It means progress. A speaker dwelt on this feature as a most important one, remarking that a million dollars had been spent in diffusing knowledge where a thousand had been in advancing it; for the association has never had an endowment worthy of the name, any more than its British prototype had till Dr. Caird gave to the latter ten thousand pounds at the recent Dundee meeting—a memorable incident, the announcement of which and the enthusiasm which greeted it, I had the rare felicity to witness.

"Some of the Next Steps in Botanical Science" was the title of the annual address of the retiring president, Dr. Charles E. Bessey, which was followed by a reception at the Hotel Statler.

Gleaning here and there among the many papers read I note much interest expressed in insects, and their function as hosts for the development and dissemination of disease germs. So important has the study of these disease carriers become that there is a demand for sources of laboratory material for investigating the subject by experiment. The programme promises several important contributions to our knowledge of this subject, which I will report next week.

Prof. Herbert Osborn presented a novel theory of the cicadas. He maintains that they do not sound their well-known note as a call to their mates, for these seem to have no organ of hearing; also, they often fly away instead of remaining to await the female. How the organ which they use could ever have been evolved without any apparent utility, is a puzzle. He propounds, though with some hesitation, the theory that the production of sound was not the real object of this organ, but only incidental to some unexplained sexual function.

Prof. E. P. Felt, State entomologist of New York, reported some observations on the biology of a blow fly and a flesh fly, which were undertaken in order to determine how long a human corpse had been dead when discovered. The observation consisted of raising these flies and noting how long a time was required for them to reach the stage of development of their larvæ and pupæ till they arrived at the same stage as those found on the corpse. The result indicated came within twenty-four or forty-eight hours of the conclusion already reached by the physicians from the stage of decay of the body.

A matter which occupied much time and drew much attention of the psychologists was the case of a boy who recently became amnesic, i. e., he lost all memory of a certain portion of his life, but when hypnotized was able while in that condition to recall and clearly describe the incidents of this period, but again lost memory on returning to his normal condition.

Another important matter was the report of tests applied to a large number of school children, for the purpose of comparing retarded children with those of normal development. The new apparatus and ingenious devices now available for testing all kinds of mental processes and capabilities are indeed a revelation to those who have not very recently examined the subject. One very clever invention shown at the meeting was a puzzle-box, which required nine successive operations to open it, which must be performed in a certain definite order.

A feature of the meeting is the addresses of the vice-presidents of the several sections of the association, which are being read afternoon by afternoon. Thus far I have been able to hear only that of Dr. Bohumil Shimek, retiring vice-president of the section of geology and geography, on "Significance of the Pleistocene Mollusks." This may seem technical enough, and formidable enough, but I note one interesting statement, viz., that these mollusks continued through this period so nearly unchanged in form that they give no clue to the age of the formation in which they are found; though they do furnish clear indication of local conditions of the places where they occur.

A timely bit of statistical information just published is the announcement that the two institutions in whose buildings we are meeting, the Case School of Applied Science, and the Western Reserve University are two of the four first-class educational institutions of Ohio, the others being the Ohio State University and Oberlin College.

As a locality to study the practical applications of science, Cleveland occupies an exceptional position, because of its great and varied manufacturing industries. One can hardly resist the lure of abandoning the lecture room to visit the multitude of important industries which invite inspection during our all too brief sojourn in this city where the coal and the iron meet as the foundation of these multifarious products.

Perhaps the economic enterprise of Cleveland which most strongly holds the attention of all the world is the three-cent trolley fare, with a system of transfers whereby a passenger can reach any point of the entire traction system of the city for this fare, instead of having to tackle so many different systems as impede and render costly our transit in Greater New York. But does it pay? Yes; all say so, and, with only two days' experience at the time of writing, I can see how this is true, for like everybody else here, I have at once contracted the habit of taking the trolley for short as well as for long distances, and it is the consensus of opinion here that one's trolley fare runs up a larger bill at three cents than at five because of the great and hardly noticed increase in the number of rides.

"The Fairy Tales of Science" Tennyson calls them; and like a fairy tale indeed it seemed to be, able to see and hear music at the same time, as shown by Prof. Dayton C. Miller, in his paper on "Photographing and Analyzing Sound Waves," before the Physics Section. Prof. Miller threw upon a screen a moving picture of various sound waves, simultaneously with the reproduction of the sound by a phonograph. This was followed by a paper on the "Reaction of the Room on the Sense of Sound," by Prof. Wallace C. Sabine, wherein he gave a careful study of the reflection of sound from the walls of an inclosed room, showing surprising differences in loudness at different points, so great that a person at certain points might hear with one ear a sound audible to the other. These studies may be applied practically in so modifying walls and ceiling of our auditorium as to secure the best results, and this end may be still further promoted by sounding boards properly shaped and adjusted.

Dr. William J. Humphreys of the U. S. Weather Bureau gave an illustrated lecture on the recent excursion of the American Geographical Society across the United States and back, which he characterized as the most interesting excursion known in all history. It was undertaken as a celebration of the erection of the Society's new building in New York. Many of the leading geographers of Europe were invited, making a group so cosmopolitan that twenty-six languages were spoken by its members. Eleven thousand miles were traveled, going through the northern and returning through the southern part of the United States and taking in many remote and not readily accessible places. One thousand miles were covered by automobiles, so that besides the usual scenic places, such points as Crater Lake and the Roosevelt dam were visited. At the latter the tourists had the rare opportunity of studying the effect of a heavy rainfall, which happened just at the time of their visit.

Prof. William R. Lazenby of the Ohio State University has just returned from a year abroad, during which time he made a thorough study of German forestry. He read a most interesting paper on that subject. Germany is compelled to look to her forests for fuel, and this has necessitated the elaborate system of forestry which dates from about the year 1740. Lately several varieties of American trees have been introduced. One of these, a certain kind of oak, is extremely prized for veneering and commands incredible prices, running as high as $585 per 1,000 feet for choice specimens.

Dr. George R. Wieland, research associate of the Carnegie Institution, read a paper on the "Economic Policy of the Conservative Area, from the Scientific Standpoint," in which he dwelt upon the ruthless destruction of whales, far more valuable than seals, and of other valuable animals, instancing as one group which may easily be protected, the turtles, by reserving the Dry Tortugas as a protected area for them to breed in. An effort is now being made to induce government to take prompt action in this matter.

Judson C. Wall, tax commissioner of New York city, presented an argument for industrial education, urging the passage of the Page bill, now pending in Congress, which provides for payment by the general government in aid of the several States, to establish educational institutions for this purpose. The section unanimously adopted a resolution favoring the passing of this bill.

A spirited discussion ensued, which showed unanimous sentiment in favor of the measure. Principal Monroe, of the Normal School at Montclair, N. J., maintained that boys are not now as a rule getting a proper kind of education. They should be trained by men, not by women. He spoke of the recent action of the New York Legislature in equalizing the pay of the sexes, as pernicious in that it drives out male teachers, which sentiment was warmly applauded.

Prof. J. Pease Norton of Yale read his vice-presidential address to the Economic Section, "Comparative Measurement of the Changing Cost of Living." He thinks that the influence of tariff legislation has been overrated, inasmuch as the advance in cost of living is world-wide, giving detailed analysis for which space here is lacking.

My own paper followed, and was on the "Public Bath Problem."

Friday's session of the Section was replete with important contributions beyond space limits here to abstract, including a paper by Commissioner John I. Murphy of New York city on "The Observed Effects of a Decade of Tenement House Legislation," wherein he stated that owing to prolonged litigation with owners hostile to the law, the provisions of it could not be fully enforced until about four years ago, but the results already attained were most gratifying. There has not been a single loss by fire in the tenements built under the new law, and the number of violations outstanding at the time of his appointment has been very greatly reduced.

"Race Suicide and Coniosis," by Dr. Robert Hessler, set forth at length the situation under abnormal air conditions. "Coniosis" means disease from breathing dust. Much stress was laid on the pernicious effect of spitting as an air infector.

Dr. L. O. Howard explained the rôle of economic entomology in the conservation of human life, which causes an economic loss of more than $300,000,000 a year; explaining that under certain conditions the house fly may carry typhoid, the mosquito yellow fever and malaria, the stable fly pellagra and infantile paralysis, the tick spotted fever, the flea bubonic plague, the bed bug oriental sore, the louse typhus fever. Sometimes the common fly may convey dysentery and tuberculosis.

A new section, that of agriculture, was established, but will not be organized till next year, when the meeting will be held at Atlanta under the presidency of Dr. Edward D. Wilson of Columbia University. Philadelphia was recommended as the meeting place in 1914, and San Francisco in 1915.

Recent Development of the Locomotive—III*

The Latest Stages in Its Evolution

By George R. Henderson

Continued from Scientific American Supplement No. 1932, Page 27, January 11, 1913

While the burning of oil instead of coal in locomotives is of quite ancient origin, having been first introduced in Russia on the Grazi-Tsaritsin Railway, it was experimentally tried in this country, but for many years had nothing to recommend it, as compared with coal, on economical grounds. The discovery of the fine deposits of oil in Texas and California, however, where coal costs $6 or $7 a ton in the latter locality, gave an impetus to this feature that was an immense benefit to the railroads in many ways. The Southern Pacific and the Santa Fe have for the last fifteen years been making considerable use of crude oil in the southwest, and in later years the substitution of oil for coal has been carried to points as far east as the Rocky Mountains and generally throughout the state of Texas. The advantages, while being enormous, have been also accompanied by certain disadvantages which prevented this from being an ideal fuel.

It was found from actual tests that four barrels of oil were practically equivalent to a ton of coal of the quality of Illinois bituminous, and, as there were usually six barrels of oil required to make up a ton weight, the ratio of heating value was as 3 is to 2. This is also in proportion to the number of British thermal units developed by burning a pound of these fuels, as mine run coal gives us in the neighborhood of 13,000 B. t. u. and fuel oil run about 19,000 B. t. u.

Another incidental advantage that has been greatly appreciated in the last few years is that this oil can be put in without physical labor and makes it possible to keep steam up on a much larger engine than could be done with coal fired by hand. The unfailing source of steam is another advantage, as trains, even with the same tonnage, can make better time on heavy grades, as there is ample steam to keep the cylinders supplied at full pressure, no matter how hard the engine is being worked.

The universal method of generating steam from oil in a locomotive is by means of a special injector or atomizer, generally called a burner, in which the oil is sprayed by the steam pressure and is burned in this form of atomization. In order to maintain the combustion, the fire-box is lined part way up with fire brick, also having a floor of fire brick, which becomes quite hot and maintains the temperature high enough to ignite the oil. Formerly it was the custom to place the burner at the back end of the fire-box, spraying the oil ahead underneath a brick arch somewhat similar to the ordinary brick arches used with coal, but the latest practice is to place the burner at the front of the fire-box and spray the oil on a flash wall without using any arch whatever. This saves considerable expense, as the arch was very costly to maintain, sometimes falling down from the motion of the engine in two or three trips. It is also found by this location of the burner that the fire-box sheets give a longer life, as the intense heat of the oil flame causes a much more rapid deterioration than with coal, and especially was this found to be the case at the seams where two thicknesses of metal were exposed to the action of the fire. With the old method of using the arch, fire-boxes would often give only one half or one third the life of coal burners, and it was frequently necessary to renew a fire-box in about one year, very largely because it was impracticable to patch the fire-box on account of the double thickness of metal above mentioned. The new method of arranging the burner has increased this life, and the practice of welding in pieces flush with the acetylene torch has also obviated the double thickness of an ordinary patch.

Even in spite of the extra cost of maintenance due to rapid fire-box deterioration, the use of oil was considered very desirable, as a dollar's worth of oil would often replace three or four dollars' worth of coal. Then, there was practically no fire thrown from the stacks, which is of great benefit in a dry country, and this feature alone led to the adoption recently of fuel oil by the New York Central and Delaware and Hudson railroads on their lines running through the Adirondack Forest Preserve of New York State. This matter was discussed very thoroughly before the Second District Public Service Commission, which finally decided that these roads should burn liquid fuel during the summer season in order to prevent the extensive forest losses which had resulted from fire thrown from locomotive stacks or dropped from ash pans.

The firing of oil is, of course, a specialty, as the supply of fuel to the burner must be regulated in connection with the engineer's operation of the throttle and the reverse lever. When the engine is standing, the supply of oil must be cut down to a very small quantity, such that it will just be sufficient to maintain steam, and as soon as the throttle is opened a larger supply of oil must be given, depending upon the amount of steam required by the cylinders. It is perfectly feasible to fire a locomotive with fuel oil without the emission of smoke, except that in periods of about every half hour it is necessary to work sand through the flues in order to clean out the soot that has accumulated, and, of course, this is accompanied for a moment by the emission of dense black smoke. When the engine is working properly, however, there is only a thin haze above the stack, although the least inattention on the part of the fireman will cause either the steam pressure to drop or the emission of large quantities of smoke.

Practically any locomotive that is suitable for burning coal can be converted into an oil burner, although there are some particular features to be borne in mind when an engine is being designed primarily for the use of liquid fuel. It is a very simple matter to construct an oil tank which shall fit into the coal space of the tender, and this is connected with hose or flexible pipes to the engine, passing through a heater so that the oil may be rendered still more fluid, if necessary. Steam jets can be used to warm the oil in the tank when necessary, and there is generally a safety connection which, in case of the separation of the engine and tender, closes the oil valve, preventing it from running over the track. The California oils are ordinarily non-inflammable at the usual temperatures, and there is little or no danger attending their use. Some of the Texas oils, however, are more readily inflammable, and it is necessary to exercise extreme caution going about a tank with an open light. Asphyxiation is also liable to occur when men go inside of tanks to clean them out, particularly with the Texas oils, and these tanks should always be steamed out thoroughly before anyone enters to do any work. The actual cost of converting a coal-burning locomotive into an oil-burner varies from $500 to $800, dependent upon the size of the engine; but, of course, the incidental expenses, such as the maintenance of storage and delivery tanks, tank cars for transporting the oil and pumping it into the storage stations, are all part of the general cost of introducing such a system, and will oftentimes amount to a great deal more than the actual equipment of the locomotives.

The large locomotive, with its heavy draft of steam upon the boiler, necessitating the combustion of great quantities of coal, has brought about a number of appliances for diminishing the work of the fireman so that he can confine his efforts to actually delivering the coal into the fire-box; everything that could save a step or an extra motion of his hands or his back having in some cases been introduced, so that he could give the maximum output for the generation of steam. The old-fashioned fire door, which was swung with a chain and which was supposed to be opened and closed with each shovelful of coal, has been found troublesome in large engines, and, therefore, pneumatic fire doors have been introduced. These are arranged so that when the fireman has a shovelful of coal ready to throw into the door a pressure of the foot upon a treadle in the floor of the cab admits air to a small cylinder which slides each half of the fire door in opposite directions, thus opening the door for the admission of coal without any further action upon his part. As soon as the foot is removed from the treadle the door closes. This, besides relieving the fireman of the extra motion and effort, insures more perfect combustion, as the door is naturally closed after each shovelful of coal. Wide fire-boxes are in some cases provided with two fire doors, and it is not always as convenient for the fireman to use one door as the other, especially in connection with operating the fire door by hand, but these pneumatic devices prevent much of this trouble and assist very materially in the operation of firing.

The same principle has been applied to shaking the grates. While with short fire-boxes this was a comparatively easy operation, with the present length of furnace, which is in the neighborhood of eight and ten feet, and the width, which in some cases is eight or nine feet, it is not only necessary to shake the grates in sections, but it becomes quite difficult actually to do this work. Pneumatic or steam grate shakers have therefore been introduced in which a small lever operates the valve of a cylinder, which in turn gives the necessary travel to the grate arms in order to thoroughly shake up the coal bed to free it of clinkers and ashes.

Still another device has been introduced on the tenders in order to prevent the many steps needed when the coal has been partially exhausted and the fireman must go to the back of the tender coal space to shovel up the fuel. This mechanism consists principally of a steam cylinder placed inside the tank in which a piston is operated connecting to a false or inside bottom of the coal space, and when pressure is admitted to the cylinder the piston pushes up the back end of this false bottom, which is hinged to the front, allowing the coal to slide forward so that it will be close to the gate and not require the extra steps and movement necessary in the ordinary type of tender.

While these different items seem small in themselves, yet, when they are all introduced together on the same engine, it is remarkable how much they save the fireman from a labor that can be performed mechanically as well as manually, and I have been impressed with this upon large locomotives where firemen have been enabled to put in very much greater amounts of coal than would ordinarily be expected.

The greatest improvement, however, has been in the development of the automatic stoker, which not only combines the several features above mentioned, but actually brings the coal from the tender and puts it in the fire-box. The first type developed was probably that invented by Mr. Kincaid, a former engineer on the Chesapeake and Ohio Railway. This was really a steam shovel and placed back of the fire door, coal being thrown in the hopper from the tender by the fireman with a shovel, the apparatus, however, delivering the coal into the fire-box. This represented very largely the ordinary method of firing, as the fuel was thrown on the top of the fire in the furnace and regulated the supply to be put in in large or small quantities and at regular intervals, so that the smoke production could be better controlled. There were means for distributing the coal to different portions of the box, and I have seen engines come in from a run with as level a fire as could be desired, the firing having been done entirely with this device.

There was, however, no arrangement to take the coal from the tender to the stoker, and we think this is very important. Quite a number of stokers have recently been developed, in some of which coal is thrown in as in the Kincaid by a steam piston, the valve of which is moved by a small engine, the speed of which can be regulated, and in others the fuel is blown in by steam jets. There are also methods of introducing the coal below the grate, such as the Crawford and the Barnum stokers. In the first of these the coal is pushed forward under the grate by means of pistons through tubes and slowly pushes up and flows up over the grate. In the latter stoker this is done by the operation of worms similar to those used in flour mills. The coal in both cases is carried from the tender by means of worms or a conveyor. As the rate of combustion in a modern locomotive can be forced up to 200 pounds of coal per square foot of grate surface per hour, it is evident that the problem is not only to get sufficient coal into the fire-box, but also to get it in such condition that it will be ignited and burn at the desired rate. Naturally an underfeed device must be slower of ignition, but this takes care of itself, as the raw coal piles up over the slots and rolls over in the bright portions of the fire where the flame can reach to every surface of the piece and readily ignite it.

Claims for smoke reduction and fuel economy have been made, but really the principal point of the stoker is that it enables us to obtain more work out of the engine than would be possible with a human fireman. While the locomotive has increased in size and weight, its output in horse-power is generally very much below the increase in size, and, as previously stated, a very large engine will often develop no more actual horse-power than a much smaller one, although its tractive force will be very much greater. The limit seems to be the capabilities of the fireman, and, if this can be increased by mechanical means, not only shall we be able to get more power from our engines, but the fireman's work, being less laborious, will be more attractive, so that higher-grade men can be obtained who will be able to use their heads and not depend entirely upon muscle and brawn for generation of steam.

Mention has been made above of the introduction of various superheaters and reheaters for use in connection with locomotive boilers in order to increase the output of the boiler and, incidentally, the fireman. The superheater has developed on three or four different lines, viz., one, in which a number of steam pipes are placed

*Paper read before the Franklin Institute and published in its Journal.

inside of the fire or smoke tubes, allowing the steam to be further heated by direct contact with the gases of combustion after it has passed from the boiler; another one, in which there has been a combustion chamber or pocket formed in the boiler itself, into which a receptacle has either been built or subsequently placed, permitting the steam to come in direct contact with the flue gases, and, third, in which a series of pipes are placed in the smoke-box of the engine to make use of the gases after having been discharged from the flues, the steam from the boiler passing through these pipes on its way to the cylinder. It is manifestly obvious that this last method, using only the heat remaining in the gases after having been passed through the flues, will not give as high a temperature as that which extends through the fire tubes toward the fire-box; but, at the same time, there are other advantages, among which the fact that the heating surface of the boiler is not necessarily diminished by introducing this type of superheater, and that it can be applied to an existing locomotive, in many cases, without any material changes in the boiler. While the superheat obtained from the smoke-box type will average only from 30 to 50 deg. Fahr., yet the fact that the moisture in the steam is thoroughly dried out and that cylinder condensation is largely reduced, has made a very good economical showing for this type of superheater. Fig. 8 shows the Schmidt fire-tube and Fig. 9 the Vauclain smoke-box superheater.

With the fire-tube and chamber type of superheaters it is possible to get as much as 150 to 200 degrees superheat, and some recent tests have been reported in which

Fig. 8.—The Schmidt Superheater.

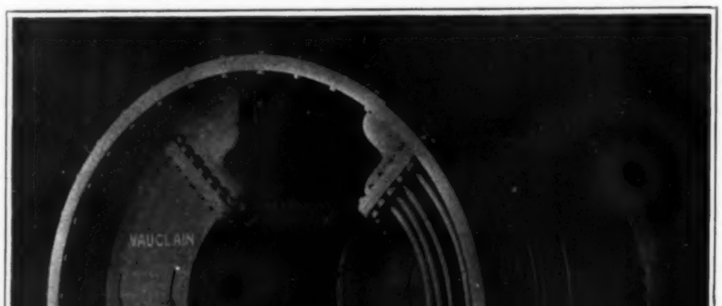


Fig. 9.—The Vauclain Superheater.

the temperature ran considerably higher than these figures. These superheaters, being exposed to the more or less direct action of the fire, are more liable to burn out than those in the smoke-box and are, also, as a rule, more expensive to apply and maintain.

There are many varieties of fire-tube superheaters, and some of them are easy of access for removal of the superheating pipes and some are difficult. The tendency in recent designs, however, has been to develop a superheater in which the elements can readily be removed without necessitating the removal of many other parts, thereby delaying the engine in the round-house and keeping it out of service. This is an important factor in railroad operation, as no matter how much economy can be obtained from any device, if it were to cause much loss of time from actual service by requiring repeated and extensive repairs, it would not receive favorable consideration.

The action of superheat upon the work of a locomotive gives, as is well known, this advantage by increasing the volume of the steam delivered to the cylinders and, at the same time, the superheating prevents in a great measure cylinder condensation, as temperature of the steam must be lowered by the amount at least of its superheat by the processes of expansion before it can be condensed in the cylinders. The economy of superheat locomotives in coal consumption varies from 10 to 20 per cent, and cases have been recorded where as much as 30 per cent economy has been obtained. We think, however, that under ordinary service from 15 to 25 per cent may be expected. This has an advantage in addition to the saving in fuel consumption, in that it also saves the labors of the fireman and enables him to give a greater output in horse-power for the same amount of physical energy expended.

It has been claimed that the increased volume due to the superheating could be utilized by operating at lower boiler pressures and thus reducing the amount of repairs on boilers of locomotives, which has become very onerous under conditions existing in modern locomotive practice; so that, even if there were no especial fuel advantage obtained, there would be a saving in boiler repairs. It must be borne in mind, however, that the loss in pressure in passing through superheaters is sometimes quite considerable, amounting to possibly 20, 30, or even 40 pounds per square inch drop from the boiler to the cylinders, and in order to make up for this and to maintain the proper working pressure in the cylinders it is necessary to operate the boiler at a considerably higher pressure than it is desired to supply to the cylinders. In Germany it is quite a common practice to have two gages, one indicating the pressure in the cylinders and the other in the boiler, and the latter is carried so as to maintain the desired pressure in the cylinders. In this country 170 pounds is a rather favored pressure for superheater engines, and, of course, the cylinders are proportioned to give the proper tractive force with this pressure, thereby making the reciprocating parts larger than would be the case with high-pressure steam. Boilers are generally, however, designed capable of carrying 200 pounds per square inch, so that at any time the safety valves can be adjusted to allow for the drop in pressure passing through the superheater. Of course, it means a certain amount of lost work, and in some cases superheaters have been arranged in which the steam passes through a single loop in the fire tube instead of the double loop, as ordinarily used. This would naturally reduce the loss about 75 per cent, and this means a great advantage in the operation of the engine.

The action of the fire on these inside tubes when steam is not passing is sometimes prevented from overheating them by means of an automatic damper in the smoke-box, which closes when no steam is passing through the superheater, thereby preventing the overheating of these pipes.

With superheaters of the chamber type it has been found that the large volume of steam outside of the throttle at times prevents a prompt response of the locomotive to the engineer's movement of the throttle lever; in starting, for instance, this chamber must fill up with steam before the pressure will accumulate in the cylinders sufficiently to move the train, and upon closing the throttle the expansion of this steam causes the engine to run farther than would otherwise be the case. It has been suggested that the throttle valve be placed outside of the superheater in order to overcome this difficulty, but this, of course, has been open to the objection that when standing the superheater might fill up with water, endangering the cylinders when the engine is started.

The whole superheater question is, in a measure, in its infancy, and, while there are a great number in use, yet we do not feel that there has been a sufficient amount of experience with them in this country so that all the benefits and difficulties can be as yet definitely determined. Anything that will increase the output of a locomotive will be looked upon with favor, unless, as stated above, there may be delays owing to necessary repairs that may more than make up for the efficiency of the engine when in operation. Of course, it must always be remembered that such devices have their benefit only when the engine is actually working steam, as on an up grade, or working on a level. During times of running down hill, standing at stations or terminals, remaining on side tracks or in the round-house, these advantages are absolutely unavailable.

From a number of tests made at the Purdue University by Prof. Goss, in which the running of the engine was intermittent, they found that the steam consumption per unit of work delivered was increased, owing, no doubt, to the cooling of the cylinders and the connected parts, and that this loss increased with higher steam pressures. When the programme of operations was intermittent with equal periods of running, the loss was found to be from 5 to 10 per cent more than that under constant running, and when the reduction by stack losses and periods of idleness were also considered, the results were about 20 per cent less favorable than during constant operation. This, however, does not consider the absolute uselessness of this or any other device, when the engine is running down hill or standing, and the additional expense for its original application to a locomotive means a constant interest charge. These things should all be considered in making any final estimates as to the value of this or any other economical device, but they are too often overlooked in the enthusiasm of those who are anxious to make a saving in coal consumption.

Reheaters have much the same function as superheaters, except that this term is applied to such devices as impart heat to the steam in its passage from the high-pressure to the low-pressure cylinders. The low-pressure cylinder, naturally, is that which produces the greatest amount of condensation, and, if we are able to reheat the steam after it has exhausted from the high-pressure cylinder, we will save considerable condensation in the low-pressure cylinder. Reheaters are seldom used alone, but are generally used in connection with superheaters which heat the steam before passing into the high-pressure cylinder. The exact amount of saving to be accomplished by a reheater is not definitely known, but it is probably somewhere in the neighborhood of 5 to 10%.

Reheaters are generally either of the box type or of the smoke-box type, and in design they resemble an ordinary superheater of these two varieties.

Feed-water heaters are of a similar nature and construction, although they are generally made of the box type. The flexible boiler makes a very convenient use of the front section by placing therein a reheater, and even in some cases with rigid boilers where the length would be too great for the application of tubes satisfactorily a feed-water heater is placed in the front end and the water from the injectors flows through this feed-water heater, which is warmed by the gases of combustion after passing through the flues.

It has been customary, in many cases, to run with this section full of water, the water then passing from the top to the boiler, being fed in near the bottom of the feed-water heater. The electrolytic action, however, in many cases causes trouble and pitting of the flues and sheets, although the boiler itself is not affected in a similar way. This seems to be worse in good water districts than where scaly water is used, and it is thought to be due to the oxygen carried in with the water. The latest practice has been to connect this with the steam space directly and run it at the same level as the water in the boiler, making this really an extension of the boiler, and, while it seems somewhat strange that such should be the case, the economy, which is from 5 to 10 per cent, seems to be practically the same whether this acts entirely as a heater or whether it is connected up to form an extension of the boiler.

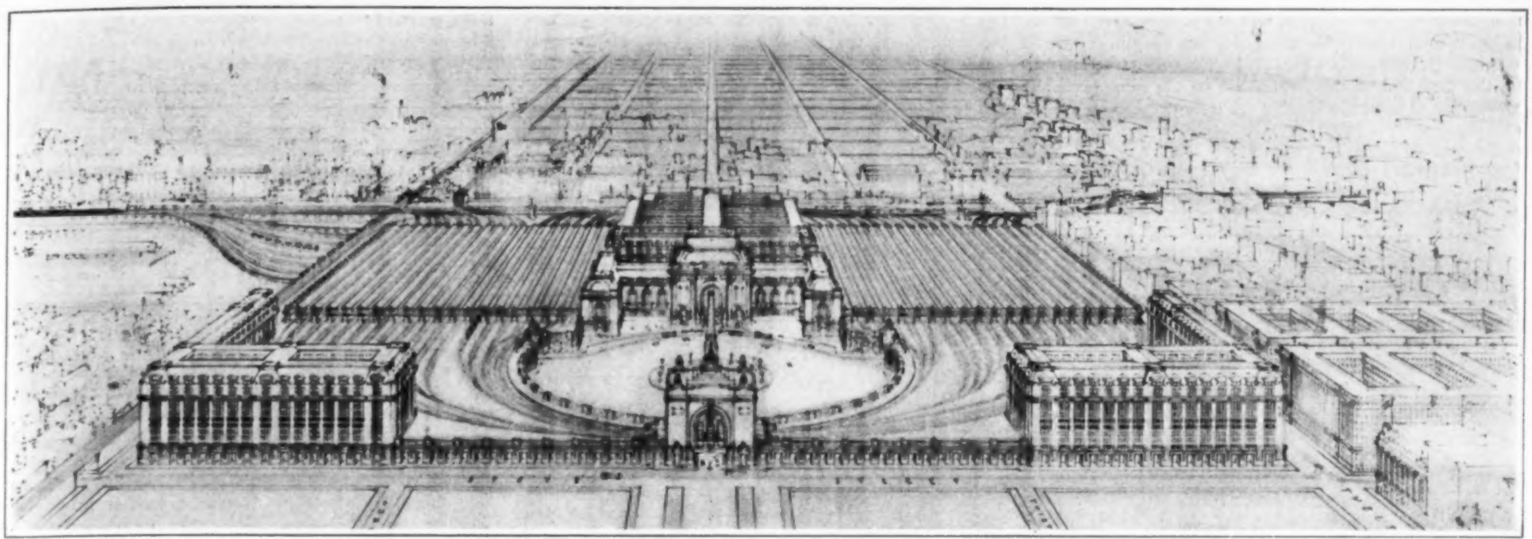


Fig. 1.—Perspective Showing Jarvis Hunt's Proposed Passenger Terminal for Chicago.

A New Terminal Plan for Chicago*

A Proposed Remedy for the Present Unsatisfactory Situation

A NEW plan for a radical re-arrangement of railroad terminal facilities in the central district of Chicago has been advanced by Mr. Jarvis Hunt, of that city, an architect prominent in the design of railroad terminals and other structures. The plan is proposed as a substitute for and improvement upon the numerous schemes which have been advanced from one source and another for some time past, as a means of remedying the unsatisfactory terminal situation in Chicago. Mr. Hunt's idea, while in some respects more radical than others that have been proposed, involves other features which make for simplicity and economy, so that as a whole the plan has been very favorably received by railroads and public officials.

The primary feature of the new plan is to straighten the course of the Chicago River between Van Buren and 20th streets, eliminating the present curvature which takes it to the eastward and digging a new channel on a line 175 feet east of Canal Street. This operation would make available for terminal purposes a large tract which at the present time is cut up by the river in such a manner as to frustrate any systematic terminal plan. The map reproduced in the accompanying illustration, Fig. 4, shows the present course of the river, with the straightened channel indicated by dotted lines. This map also indicates the present railroad ownership of real estate in the central business district of the city, and it is in its relation to this factor that the plan is especially strong. It will be noted on the map that all of the property affected by the diversion of the river is now in railroad ownership, so that the procedure preliminary to any such work will be greatly simplified. It will be noted, moreover, that the new plan contemplates the establishment of the terminal in the space between 12th Street on the north, Archer Avenue on the south, State Street on the east and the new course of the Chicago River on the west; all of which tract is also in railroad ownership. This district comprises but a small part of the area at present devoted to railroad terminals in the city, and yet within its boundaries the new plan would provide accommodations equal to six times the bulk of the traffic, both passenger and freight, that is handled now by all of the railroads combined. As a consequence, vast tracts of extremely valuable real estate now held by the various railroads in the business district would be released. The sum of two hundred million dollars is named by Mr. Hunt as his estimate of the value of the property which would no longer be needed for terminal purposes.

Although only the general features of the new plan have been announced to the public, Mr. Hunt has worked out the details and maintains that it will fulfill all the necessities of both the public and the railroads, that every objection which has been raised to other plans is met by this one, and that it embodies all the features of convenience and economy which should be an essential part of any such comprehensive undertaking. The manner in which he provides for the necessities of the railroads may be indicated roughly as follows:

The plan contemplates the abandonment of all present passenger and freight terminals within the business district so far as through traffic is concerned. Whatever value the various railroads find in their present terminal locations for local or suburban traffic could be held by retaining the present terminals for this class of business; but so far as through business of all kinds, passenger and freight, is concerned, the new terminal contemplates taking care of all of it. The railroads which enter the city from the south would come in on a line parallel with the east bank of the river. Those which come from the north would enter the terminal along the same line but from the opposite direction, and the railroads which come in from the west would cross the river at a point near 15th Street. The accompanying illustration, Fig. 2, shows these respective routes and the track layout as they enter the terminal.

Referring to Fig. 3, the general plan of the entire terminal may be noted. The shaded area bounded by Fifth Avenue, 12th Street, New Street and 16th Street is a vast system of freight houses, as is also the somewhat similar layout bounded by State Street, 16th Street, Fifth Avenue and Archer Avenue. Both of these systems of freight houses handle both in-bound and outbound freight. The special feature is that the freight house doors are on the street level, providing no grades on the wagon haul; while the outbound freight tracks are below the street level and the in-bound freight tracks are above street level. Both in-bound and out-bound freight, therefore, is handled by a gravity conveying system. The provision of the two separate systems of freight houses, distinct and yet working into each other, avoids all confusion of wagon traffic between the several sides of the city, for the traffic from the south side takes the south freight terminal while teaming from the west and north sides takes the other.

The area bounded by Fifth Avenue, 16th Street, New Street and Archer Avenue is occupied by team tracks at street level.

Along the east bank of the re-located river, from Harrison Street to 20th Street, would be erected a series of warehouses. These would be situated between rail and water transportation, and yet readily accessible to teaming.

The district between 12th and 16th streets, State Street and the river is covered by an immense passenger terminal, the western half of which, it will be noted, is superimposed above the one system of freight houses.

* Reproduced by courtesy of the Editor of *Railway and Engineering News.*

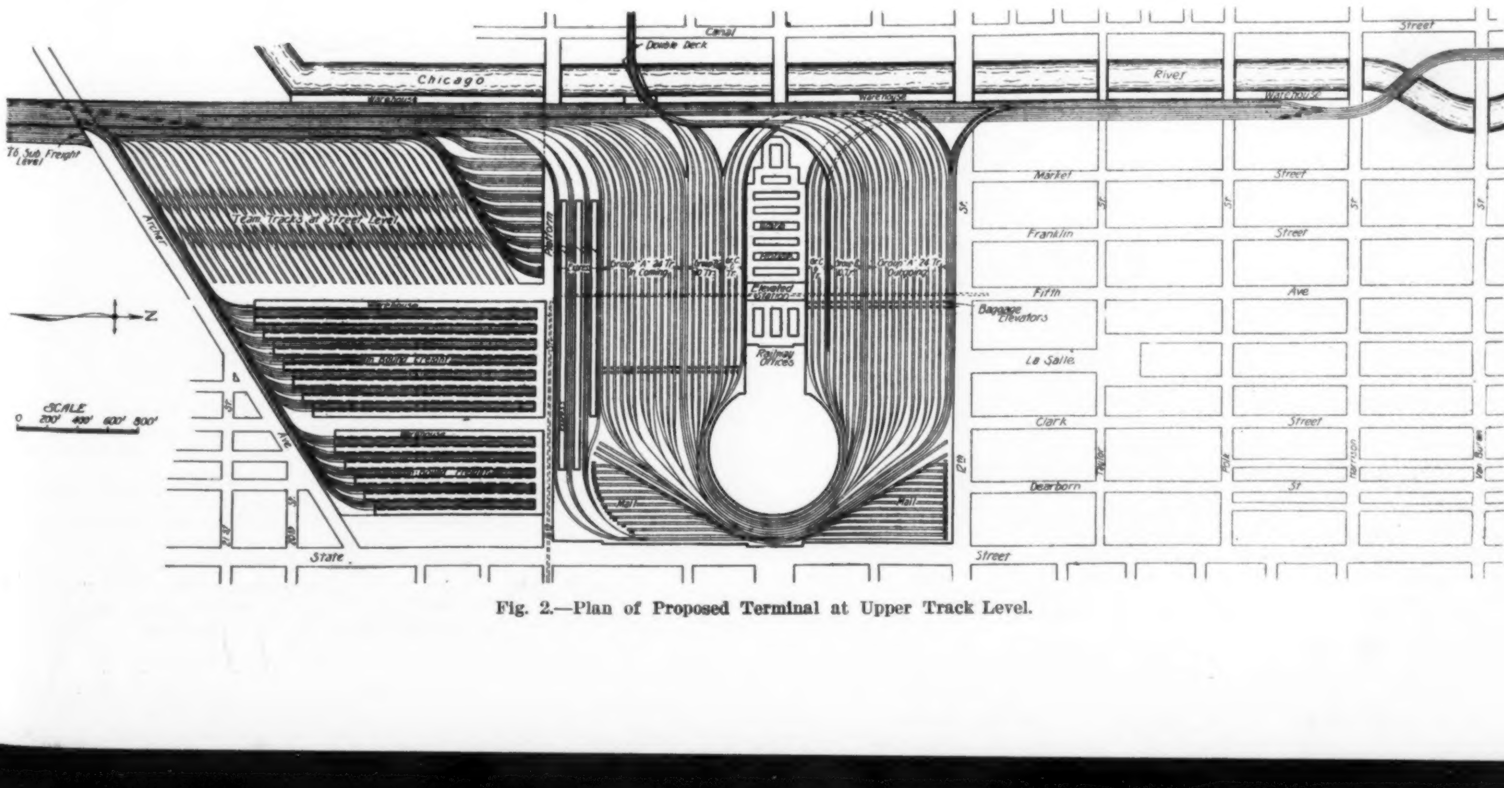


Fig. 2.—Plan of Proposed Terminal at Upper Track Level.

The track layout, in Fig. 2, and the perspective, Fig. 1, indicate something of the design for this station. Though not clearly indicated in Fig. 2, the trackage there shown at the west end of the terminal is on the same level as the in-bound trackage serving the freight houses. These not be necessary for many years to come, and the new terminal if adopted would be worked out in part only until the growth of the city called for a full completion of the plan.

The advantages to the public at large in such a re-loca-

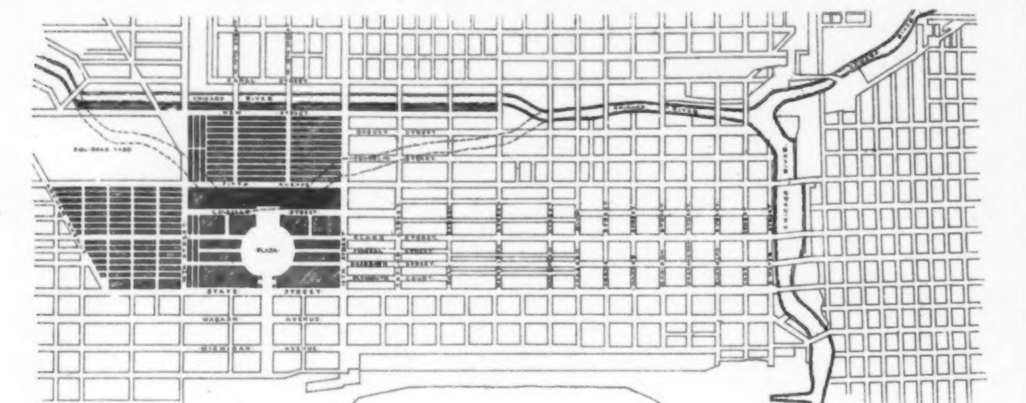


Fig. 3.—Map of Business District. Shaded Area Covered by Proposed Terminal.

two systems of trackage, however, in no way conflict with each other, and all crossings at grade are avoided. The same may be said, in fact, of all trackage, passenger and freight, throughout the terminal, the levels being ingeniously arranged so that no crossings at grade exist.

Referring again to Fig. 2, all the trackage coming into the passenger terminal loops around a central area which is called the Plaza in the plat shown in Fig. 3. The railroads coming from the south use the 24 tracks designated as group *A*. The railroads coming from the west use the 10 tracks designated as group *B*, and the railroads from the north use the 6 tracks shown as group *C*. All the tangent portions of this trackage are served by passenger platforms and covered by train sheds of Mr. Hunt's design, similar to the Bush train shed. There is thus a vast expanse of passenger platforms, of which those on the south half are devoted to incoming passengers and those on the north to outgoing passengers. It will be noted, furthermore, that each length of platform is sufficiently long to accommodate two trains simultaneously; so that the train accommodations of the terminal at any one time are equal to double the number of tracks.

The platforms for express business are indicated upon the plan, at the south side of the station, the mail business at the stub end tracks on the front or east side, and the baggage accommodations are cared for by the rows of baggage elevators at both incoming and outgoing platforms.

Structures are provided in the center of the station for warehouses and railway offices, and at this point would be located the elevated railroad station.

The present railroad business of Chicago amounts to approximately 118 passenger trains per hour. The new terminal contemplated in this plan of Mr. Hunt's would accommodate no less than 600 trains per hour. The freight station facilities of the city of Chicago provide now for about 3½ miles of platform accessible to wagons. The new station would provide no less than twenty-one miles of wagon accommodation at the freight house. It will be noted, therefore, that both as regards passenger and freight facilities, the new station would provide for a six-fold expansion of the present railway business of the city. In all probability such accommodations would

tion of the railroad terminals would be very important. The map shown in Fig. 4, indicating the railroad ownership of property in the city at the present time, emphasizes the well-known fact that the outlet of the central business district to the south is restricted to four streets, a situation which greatly congests street traffic and is already handicapping in a serious way the expansion of the district. The new terminal opens up new thoroughfares between the central business district and the south to make a total of nine, and expands the present number of nine streets opening into the railroad freight yard district to twenty streets. In addition, all means of communication are wide open between the east and the west sides of the river, and by eliminating all other railroad terminals the belt of railroad yards around the central business district is entirely done away with. It was noted above that teaming into and out of the immense freight terminal would be thrown into divergent streams which would not interfere with each other, each side of the city being served by the freight house system adjacent to it. The improvement in the straightening of the river, from the standpoint of navigation, is obvious.

The present unsatisfactory conditions of transfer between the various railroad stations would, of course, be dispensed with by the union station; and at the same time the problem of re-routing the city transportation lines so as to reach the various stations would be reduced to its simplest terms by the fact that all passenger business would be concentrated at one place. As to the matter of congestion, while the new plan would center all business within one terminal, this terminal is of such vast proportions that it would accommodate all with less congestion than is now found in any one terminal; moreover the arrangement would be such that all lines of traffic would pass and re-pass absolutely unimpeded. There would therefore be no obstruction or cross currents to hinder and delay.

As to convenience of location of the new terminal, it is perhaps, a matter of uncertainty as to what course the future growth of the city will take. However, Mr. Hunt is firm in his conviction, and the same idea has been maintained by Mr. F. A. Delano and others who have studied the terminal problem, that a location south of 12th Street would become, by the time such a terminal could be constructed, a central point for the city as a whole.

The financial basis of a terminal programme such as outlined above is very largely covered by the fact that two hundred million dollars worth of real estate now owned by the railroads would be released. The cost of straightening the river, Mr. Hunt estimates would not exceed five or six million dollars, including the necessary new bridges. There would be no necessity of acquiring or condemning new property for, as stated above, the area required is already in railroad ownership. As to the cost of the terminal structures proper, there is nothing architecturally elaborate or expensive in the plan, for it is all reduced to its simplest terms.

The idea of freight and passenger terminals superimposed, and the freight house trackage both above and below the street level involves, of course, the substitution of electricity for the present motive power. There is no requirement, however, for the electrical operation to extend beyond a very small terminal zone. But if the construction of the new terminal should involve more or less extensive electrification, it would, at the same time, solve many of the difficulties of such an undertaking by the fact that it eliminates the present intricate yard layouts which in their connections one with another almost forbid any electrification plan under present conditions.

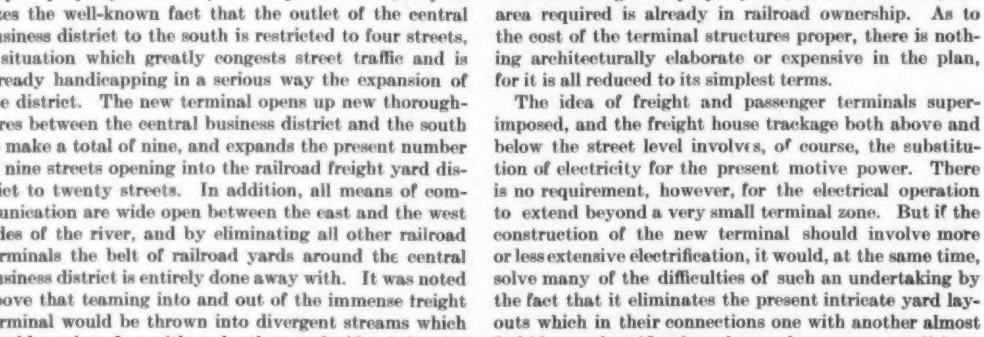


Fig. 4.—Map Showing Railroad Ownership of Property in Central District of Chicago.

The Construction of Surfaces With Bituminous Materials*

A Study of the Causes of Some Failures Encountered

By Arthur H. Blanchard, M. Am. Soc. C. E., Professor of Highway Engineering, Columbia University

VARIOUS kinds of bituminous materials have been used in the United States in the construction of roads and pavements for over fifty years. The introduction of the use of bituminous surfaces and bituminous pavements in the construction of highways outside of built up districts is of comparatively recent origin in this country, dating practically from 1906. Since that period the growth of the use of asphalts, asphaltic oils and tars has been exceedingly rapid. For example may be cited the increase in the yardage of bituminous surfaces and bituminous pavements constructed with bituminous materials, not including light oils, under the jurisdiction of eight State highway departments of the East. In 1908 the total yardage was 416,700, while in 1911, 17,749,000 yards were constructed. The discussion of this subject will be presented in the form of a brief *résumé* of typical current practice and a review of some of the causes of failure of the different types of bituminous surfaces and bituminous pavements.

In order to avoid misunderstandings, the various methods of using bituminous materials referred to in this paper will be explained by the following definitions:

Bituminous surfaces are those consisting of superficial coats of bituminous materials with or without the addition of stone or slag chips, gravel, sand or materials of a similar character.

Bituminous macadam pavements are those consisting of broken stone and bituminous materials incorporated together by penetration methods.

Bituminous gravel pavements are those consisting of gravel and bituminous materials incorporated together by penetration methods.

Bituminous concrete pavements are those having a wearing surface composed of stone, gravel, sand, etc., or combinations thereof, and bituminous materials incorporated together by mixing methods.

* Paper presented before the American Road Congress at Atlantic City.

Bituminous surfaces are usually constructed on macadam or gravel roads, or on bituminous pavements or cement concrete pavements. A notable innovation is the use of bituminous surfaces on brick and wood block pavements. In the case of roads, the mode of procedure is to thoroughly clean the surface by sweeping with hand brooms or horse sweepers or combination of these methods. The bituminous material, which is generally heated, is applied to the surface with the aid of pouring cans, hose attached to gravity tanks, hand drawn gravity distributors, horse drawn or power driven gravity distributors and pressure distributors. After a varying interval, some kind of mineral coating is generally applied to cover the bituminous material.

The causes of failure of bituminous surfaces are numerous. They may be considered from the standpoint of the condition and character of the original surface, the material used, the method of construction or local conditions.

The failure of bituminous surfaces from the standpoint of the character of the original surface is many times due to failure on the part of those in charge to place the surface in satisfactory condition before the application of the bituminous material. Many cases are noted where bituminous materials are applied over a surface in which are found many pot holes and ruts, or which is dirty due either to accumulated dust and dirt or to the original method of construction. With certain kinds of materials a damp condition of the surface has resulted in failure.

From the standpoint of the physical and chemical properties of the material, many instances may be cited in which failure is due to materials not having the proper characteristics for the conditions under which they are employed. As an example might be cited the case of a prominent thoroughfare in one of our large cities which is subjected to motorbus traffic and a large amount of motor car and horse drawn vehicle traffic. This road is constructed of gravel upon which has been applied an asphaltic oil and gravel top dressing. The surface at the present time in many sections is full of ruts caused by the traffic pushing the material from side to side. Again the large percentage of volatile constituents contained in certain asphaltic oils has rendered surfaces constructed with them unsatisfactory because of the long period required for these surfaces to "set up" so that the bituminous material will not track or the carpet thus formed will not creep and form waves and humps. In certain cases the use of light oils on tar or asphalt surfaces has softened the original bituminous surface to such an extent as to render the road or pavement unsatisfactory for use.

From the standpoint of construction, we find failures due, both to the use of too small an amount of the bituminous material and an excess of material. Improper application, resulting in uneven distribution, is accountable for many failures of bituminous surfaces, while in other cases a lack of sufficient covering of stone chips or material of a similar character has rendered the surface sticky, mushy, sometimes in the first season, but sometimes not until the second summer.

There are numerous instances where bituminous surfaces have been adopted under conditions which call for the construction of bituminous concrete pavements or even some type of block pavements. A mat type of construction, which has been employed to a considerable extent, has proved inefficacious in cases where horse drawn vehicle traffic has been more than a certain amount in combination with a motor car traffic which in amount was not sufficient to satisfactorily iron out the calk holes caused by the horse drawn vehicle traffic. There are cases where esthetics should govern the selection of the type of surface and generally in such cases the black or brown surface resulting from the use of bituminous material does not harmonize well with the environments.

Bituminous macadam and bituminous gravel pavements are of many types, one of the primary differences in construction being the use of one or two applications of the bituminous material. The efficacy of many of the types depends upon the combinations of sizes of broken stone or gravel and the combination of bituminous materials used when two applications are employed. Variations in types also exist dependent upon the manner in which the different courses may be filled and the treatment of the filled course prior to the application of the bituminous material. The one application method is very similar in its simplest form to the construction of a bituminous surface except that the bituminous material is applied upon a much more open surface. In the case of the two application method in certain instances an attempt is made to build up a two course pavement, while in others the second application is in reality used as a seal coat.

Unfortunately many are the instances where improper bituminous materials have been employed. In some cases the materials were satisfactory in themselves but were used improperly. Many engineers having charge of bituminous work do not appreciate the cold fact that different types of bituminous materials have entirely different physical properties and require entirely different treatment in use, although they may have been purchased under one and the same specification covering chemical and physical properties. In some cases entirely unjustifiable combinations of materials are employed. For instance, one case is in mind where an asphalt of excellent characteristics was used for the first application, while for the second application an asphaltic oil having decidedly solvent and fluxing properties was employed. Overheating of the material has likewise proved the cause of many failures as thus the properties of the materials are sometimes changed and in many cases the materials are ruined.

Under the heading construction, we find failures due to the uneven distribution resulting especially from the improper use of hand pouring pots and hand drawn distributors and also in many cases when horse drawn or power driven distributors are employed. Many unsatisfactory bituminous macadam pavements result from the use of the wrong sizes of broken stone. One instance will be cited where a hard broken stone ranging from 2 to 3½ inches was used for the wearing surface. After rolling, 1½ gallons of bituminous material was applied and the road finished with a layer of chips. The rapid formation of fine cracks due to the rocking movement of the individual stones under traffic finally resulting in raveling and general disintegration, is of common occurrence. Segregation of sizes of stone preventing uniform penetration results in weak spots in some cases and "fat" spots in others. In certain cases after a rain the construction has been carried on before the broken stone immediately below the surface has dried out. Many of the causes attributed to the failures of bituminous surfaces may likewise apply to bituminous macadam and bituminous gravel pavements.

Bituminous concrete pavements other than sheet asphalt and pavements laid by companies as proprietary articles have received more attention during the past season than at any time since the days of Abbot, Leverich, Scrimshaw, and Van Camp. Less fear of litigation proceedings and the introduction of economical mixing machines equipped with heating attachments have exerted a marked influence. But, furthermore, the rapidly growing recognition of the inherent advantages of bituminous pavements constructed by the mixing method has been largely instrumental in its adoption for traffic conditions for which it is believed to be economical and suitable.

This type of bituminous pavement is constructed usually by one of three methods. These methods, although overlapping to a certain extent, may be described as follows when broken stone is used as an integral part of the mineral aggregate.

Type A consists of so-called one-size crusher run broken stone mixed with bituminous material. It should not be considered that the designation, "one-size crusher run stone," means an aggregate composed of broken stone of uniform size. This term as used here refers to the product obtained at a crushing plant which passes over one size of screen holes and through the next larger or passes through a screen of one size of holes and is retained upon a screen having smaller holes. It is evident to those familiar with the operation of crushers that the product thus obtained does not usually consist of stone of uniform size. For example, broken stone commercially designated as "three quarter inch," used in the vicinity of New York city, is obtained in some cases by passing over ½ inch and through 1¼ inch openings. The size of the stone varies from one inch to one eighth of an inch. It is self-evident that this variation in size produces a more stable pavement than if the aggregate consisted of broken stone of uniform size. Type A has been constructed by both hand mixing and machine mixing and by using both unheated and heated stone. Many kinds of bituminous materials have been used while in some cases one kind of bituminous material has been used in the mix and another kind for the seal coat; one of the most common combinations being the use of tar in the mix and asphalt for the seal coat.

Type B consists of one size crusher run broken stone and sand or other fine mineral matter mixed together with bituminous material. The wearing surface of this mix is sometimes finished by rolling in fine stone chips, but generally a seal coat is used together with fine mineral matter for a top dressing. When constructed on a commercial scale, the mineral aggregate is always heated and mixed in a specially constructed machine. Usually the same grade and type of bituminous material is used for the mix and the seal coat.

Type C consists of a wearing course composed of a graded aggregate of broken stone and sand with or without other mineral matter, which aggregate is mixed after being heated with a bituminous cement in a specially designed machine. As with Type B this pavement is finished with and without seal coats of bituminous material. The Topeka and the Bitulithic pavements may be cited as examples of Type C.

Having reviewed the fundamentals of the various types, consideration will now be given to causes of failure of some bituminous concrete pavements. It should be noted that the percentage of failures of bituminous concrete pavements is much smaller than in the case of bituminous macadam and gravel pavements.

Poor and unsuitable materials have been accountable for certain failures. Attachment for a material of a certain type has led to a blind adoption of any material belonging to a given class. For instance, in one case coming under the writer's observation, crude coal tar from one gas works had given good results on the average. Based on this fact any crude coal tar was finally used, although those in authority had had an object lesson in a failure due to the haphazard purchase of crude coal tar. Experiments in Rhode Island and in the Borough of Queens seem to have demonstrated that high carbon tar of a certain consistency is not as satisfactory or advisable for a seal coat as some types of asphalts, when the percentage and volume of horse drawn vehicle traffic is large. In some cases an apparent cause of failure has been an excess of flux or of the volatile constituents in asphalt cements. Pavements constructed with such materials many times are wavy, due to the movement of the surface under heavy traffic. Many cases are reported where materials have been overheated at the construction site due to the belief that all materials may be and even should be heated to the same temperature before using, and that it is impossible to injure bituminous materials by heating to high temperatures.

During construction there are various details which demand careful supervision. Either too large broken stone or stone of too uniform size may cause a failure. Especially is this the case with very hard and tough broken stone. The rocking of the stone causes the formation of fine cracks which eventually lead to disintegration. Naturally the amount and character of the traffic is intimately connected with the condition of the pavement, but cases have occurred where failure, even under very light traffic, was due to using large uniform size broken stone for the mineral aggregate of the mix. Poor combinations of sizes of broken stone and sand have resulted in segregation during mixing, transportation or spreading, resulting in a pavement of varying density and stability. Overheating of the mineral aggregate has caused burning of the bituminous material in some instances or the formation of a thin film of bituminous material over the broken stone, which is not of sufficient amount to bind the adjacent stones together. The use of a wet aggregate will usually result in a poor mix with consequent unsatisfactory results. In many instances the seal coat has been applied ununiformly. The result is either uneconomical, due to the necessity of a second application before seventy-five per cent of the surface requires treatment, or the disintegration of the pavement wherever bare spots occur in pavements where a coarse aggregate was used and where there is considerable horse drawn vehicle traffic. Although of minor import to-day, some failures have been caused by using with unheated stone bituminous cements which will not adhere satisfactorily or which only mix with great difficulty under such conditions.

Many failures are due in both the case of bituminous macadam and bituminous concrete pavements to poor foundations. Sufficient attention has not been paid to this important part of the pavement.

Many of the above causes of failure would be eliminated if engineers would devote more time to a consideration of the physical and chemical properties of the materials which they employ. Records should be at hand covering these data and details of the success or failure of every road noted. If a bituminous material laboratory is not connected with the department, it should not be either expensive or difficult to secure certified analyses made by reputable chemical engineers.

In closing the writer wishes to emphasize the fact that a careful consideration of the causes of failure of bituminous surfaces and bituminous pavements constructed during the past five years will result in material benefit, inasmuch as a comprehensive knowledge of the various causes of failure is one of the most valuable assets of engineers having in charge the construction and maintenance of bituminous surfaces and bituminous pavements.

Aeroplane Altitude Records Made By Women

Mlle. Melli Beese, last autumn, at Johannisthal, attained a height of 1,200 meters with a passenger in an Etrich-Rumpler "Pigeon" monoplane. This record was broken on November 22nd last by Mlle. Galantschikoff, a Russian aviatress, who, with a 100 horse-power Fokker monoplane, fitted with an Argus motor, attained 2,200 meters in 30 minutes and volplaned to earth in 6½.

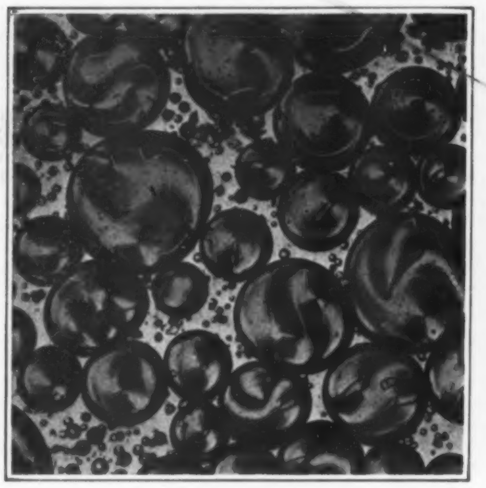


Fig. 1.—Liquid Crystals of Para-azoxyphenetol in Polarized Light.

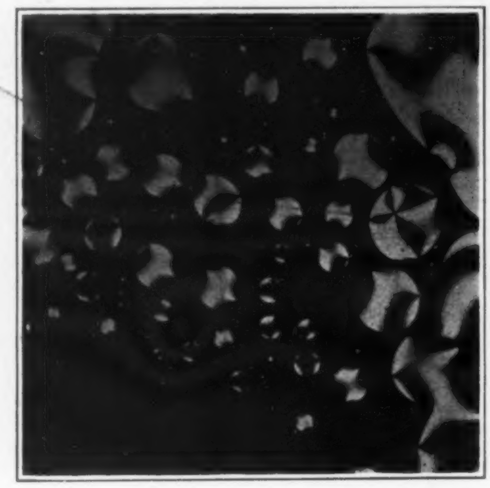


Fig. 2.—Liquid Crystals of Para-azoxyphenetol Between Crossed Nicols.

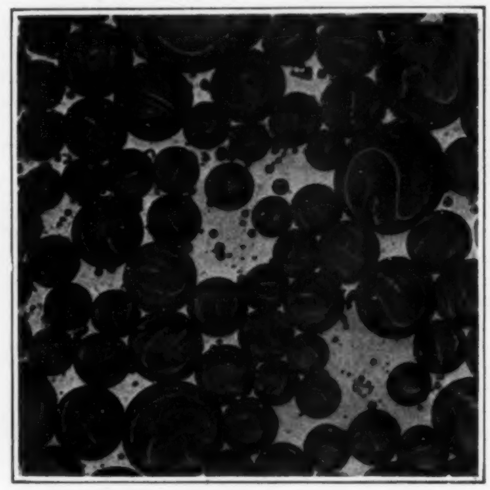


Fig. 3.—Liquid Crystals of Para-azoxyphenetol in Natural Light.

Liquid Crystals*

Fluids Which Possess Shape and Structure

By E. Jobling, B.Sc., A.R.C.Sc.

With illustrations from photographs taken by Professor Lehmann

When it was announced more than two decades ago that substances had been discovered, which though liquid, exhibited the properties usually associated with crystals, an outburst of adverse criticism was the immediate and not surprising result. After the first stir had subsided the attitude became one of unreasoning scepticism; the observations themselves were discredited and the disturbing conclusions calmly ignored. Time, however, has favorably modified the trend of scientific opinion, though even to-day the importance of the subject is not fully realized, and in consequence but slight attention is devoted to it. Yet the phenomenon is such a curious and surprising one that whatever interpretation be put upon it, a brief account of its principal aspects cannot fail to be of interest.

After all, only a little consideration is sufficient to demonstrate the reasonableness of the idea of crystallinity in the liquid state. On the orthodox view, a substance which is on the point of undergoing crystallization has its molecules moving about in the haphazard way which is characteristic of an ordinary fluid but immediately the temperature at which crystallization occurs is reached these are supposed to arrange themselves in a definite order according to the symmetry of the crystal to be formed. Such a conception involving as it does the *sudden* formation of cosmos out of chaos is difficult of comprehension. It must be admitted that it would be far more rational to imagine that in a liquid as it nears the crystallization temperature a marshalling of the molecules is taking place which reaches its culmination at the moment of separation of the solid crystalline form. In other words the possibility of crystallinity in the liquid state must be conceded. Let us see how far experimental evidence bears out this deduction.

* Reproduced from *Knowledge*.

EXPERIMENTAL EVIDENCE.

The discovery of liquid crystals will always be associated with the name of Lehmann for it was he who stumbled upon the first example and it is largely due to his persistent activity that we owe the rapid development of the subject.

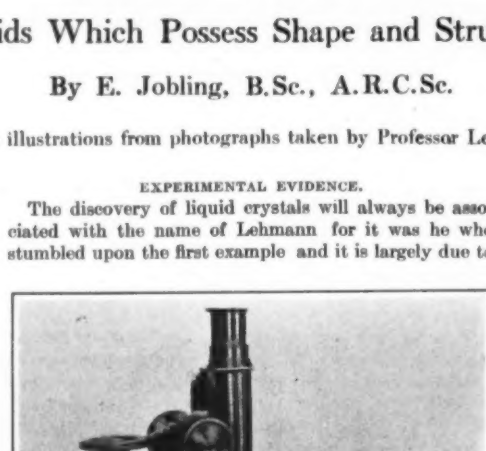


Fig. 4.—A Simple Form of Crystallization Microscope.

In 1876 in a series of experiments with his "crystallization-microscope" to which attention will soon be turned, Lehmann observed that silver iodide though exhibiting a hexagonal form at the ordinary temperature changed at 146 degrees into a cubic modification which was not only plastic but actually liquid. While still dubious as to the exact significance of this isolated instance Reinitzer in 1888 drew Lehmann's attention to a substance, cholesteryl benzoate which exhibited a double melting-point; that is to say on heating the solid melted at a definite temperature and this on further heating suddenly clarified. The intermediate turbid phase Lehmann found to be at once mobile and doubly refractive; so that taking this in conjunction with his own example he at once declared for the possibility of the existence of what he has called "liquid-crystals."

Since then examples have turned up more frequently than might have been anticipated so that there are now nearly three hundred compounds which can be brought into the same category as cholesteryl benzoate. These compounds are all organic and of very diverse structure; but instincts of compassion as well as considerations of space spare the infliction upon the reader of any but the simplest of the weird and wonderful names with which they have been labelled.

CRYSTALLIZATION-MICROSCOPE.

Before proceeding further some notice must be taken of the instrument to which we owe the discovery of and subsequent investigation upon "liquid-crystals."

A "crystallization-microscope" is shown in Fig. 4. The instrument consists of an ordinary microscope which is provided with means for raising a substance to any desired temperature for maintaining it there and for cooling it rapidly to another temperature. The heating is effected by means of a miniature Bunsen burner *A* capable of being swung into position below the center of the stage. A delicate adjustment *B* comprising a lever moving over a graduated arc is provided for the regulation of the height of the flame and by the use of an air-blast not shown in the figure the bunsen is convertible into a blow-pipe. Also fitted to the instrument are one or more cooling-blasts *C* mounted usually upon universal joints and fitted with an arc adjustment *D* by means of which the liquid upon the slide can be lowered in temperature at almost any desired rate. It is thus possible by a suitable combination of both heating and cooling to conduct a microscopic examination of a substance for quite a long time at a constant temperature. In the modern complicated instruments the arrangement of the parts is slightly different from that shown in the figure while such additions as water-jackets for the lenses and electric connections on the stage are provided.

Let us now consider any one of the many well-known substances which yield "liquid-crystal" droplets and follow its behavior under the microscope. A little of the substance—usually in some suitable solvent in order to

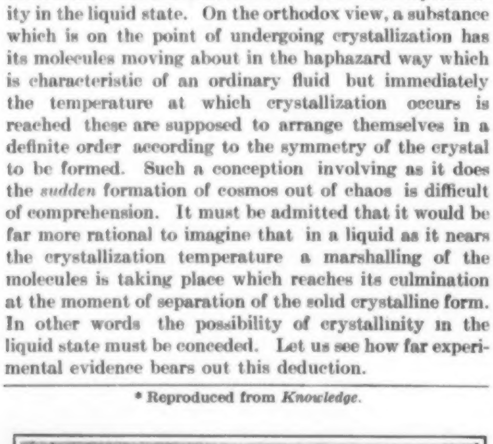


Fig. 5.—Liquid Crystals of Para-azoxy Anisol in Natural Light.

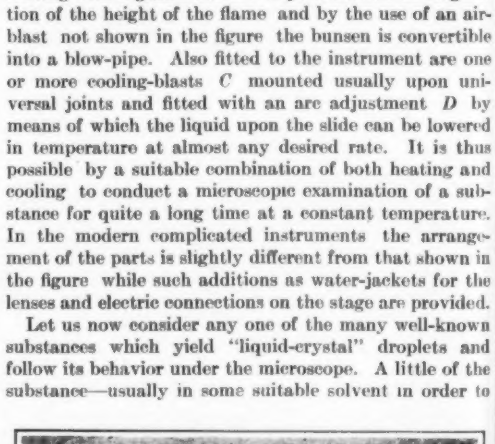


Fig. 6.—The Same Drop as in Fig. 5, but in a Magnetic Field.

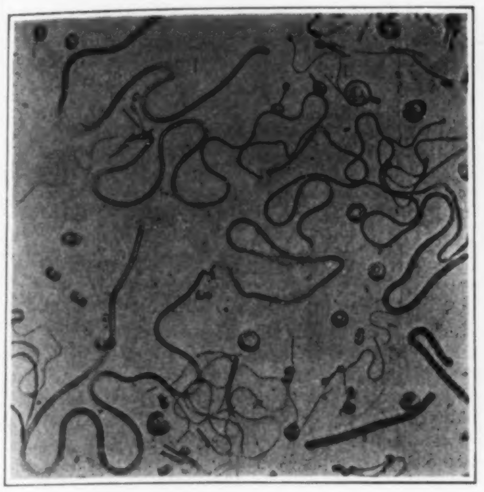


Fig. 7.—"Living Crystals" of Para-azoxy Cinnamic Acid Ethyl Ester in Natural Light.

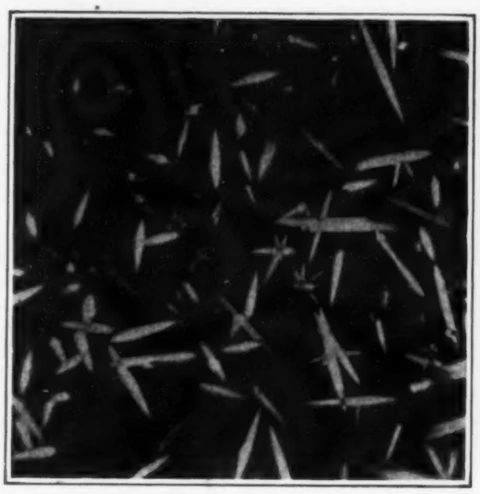


Fig. 8.—Liquid Crystals of Ammonium Oleate Between Crossed Nicols.

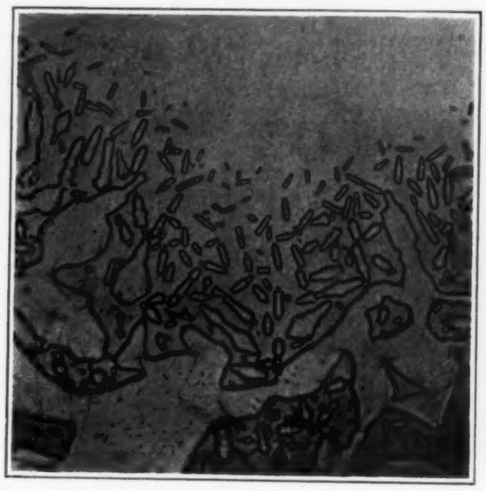


Fig. 9.—Liquid Crystals of Para-azoxybenzoic Acid in Natural Light, Showing Geometric Form.

get isolated crystals—is placed between two cover-glasses on the microscope stage and a very gentle heat is applied by carefully regulating the height of the small bunsen flame placed in position beneath the object-glasses. When a clear melt or solution has been obtained the bunsen is swung out of action and the air-jet then brought to bear upon the slide. In order to observe the formation and development of "liquid-crystals" it is best to rely upon their optical properties. To this end the nicols are crossed and the field of view carefully observed. When a temperature sufficiently near the temperature of crystal formation is reached points of light appear in different parts of the field and these gradually increase in size until disks of light are attained in each of which black crosses can be observed. If the plate be now touched with a needle the slight pressure is sufficient to cause distortion and as they regain their original shape when the pressure is removed there remains little doubt as to their liquidity. The appearance of the field at this stage is that of a number of cross-imprinted disks of light resembling wheels standing out upon a dark background. This continues until the temperature has fallen sufficiently low to have reached the temperature of transition of the liquid into the solid state, when the beautiful prismatic colors, indicative of the attainment of the latter condition, quickly make their appearance and replace the above phenomena.

Fig. 3 shows the appearance of the field when crystal drops of para-azoxyphenetol in olive-oil are viewed in natural light. A similar field when observed in polarized light is shown in Fig. 1, where the dichröism is clearly shown, the two colors being yellow and white. The next photograph, Fig. 2, illustrates fairly well the aspect of the field of the same substance as seen between crossed nicols.

A remarkable instance, worthy of special mention, is to be found in ammonium oelate, which Lehmann investigated in 1894. By crystallization of this substance from alcohol, crystals separate which, notwithstanding their fluidity, form well-defined bi-pyramids, with edges more or less rounded. Fig. 8 gives some idea of these regular shapes. That they are really liquid can be tested in the usual way by gently pressing the cover-glass. When two of the bi-pyramids approach one another, they arrange themselves at a certain angle and then slowly coalesce to form a larger single crystal. Yet another noteworthy property lies in their power of growth, since if a crystal be broken in two, each part grows again at the expense of the substance still in solution, and becomes a perfect crystal.

Fig. 8 shows another instance, in this case para-azoxy benzoic acid ethyl ester, in which the crystals, though liquid, reveal a definite geometric form. The field is viewed in ordinary light and the crystals are shown in the act of flowing together.

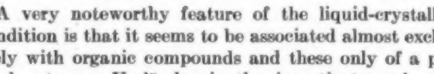
There are even one or two exceptional instances where a substance has been discovered which exhibits a perfectly definite structure bounded by plane faces and sharp angles. In other cases, and these are now becoming quite common, dimorphism makes its appearance; that is to say, the substance exhibits two liquid-crystalline phases and therefore three definite melting-points or, more accurately, transition-points. These dimorphous phases are occasionally rendered evident by their differing degree of turbidity, though usually they are differentiated by their viscosities or other physical properties. Remarkable instances of tri- and even tetra-morphism have recently come to light; but naturally such cases are very rare.

An interesting phenomenon is to be observed when "liquid-crystals" are subjected to the influence of a magnetic field; for under these circumstances the drops rearrange themselves with their principal axes in the direction of the lines of force. This is well shown in Figs. 6 and 5, where the former is a reproduction of a photograph of crystal drops of para-azoxy anisol in piperine in natural light, while Fig. 5 represents the same drops after the magnetic field has been set up. The lines of force are in the direction of sight, and judging from the dark points which have now appeared at the centers, the drops have arranged themselves with their principal axes perpendicular to the paper.

INFLUENCE OF THE CHEMICAL CONFIGURATION.

A very noteworthy feature of the liquid-crystalline condition is that it seems to be associated almost exclusively with organic compounds and these only of a particular type. Vorländer is the investigator who has devoted special attention to this branch of the subject, having already disclosed many relationships which may have much to do with the elucidation of the phenomenon.

The general conclusion at which he has arrived is that the appearance of "liquid-crystals" is invariably associated with a linear structure of great length, that is to say, with a structure which, when represented three-dimensionally according to the modern tetrahedron arrangement of the carbon affinities, approximates as closely as possible to a straight line. The oft-recurring para-azoxyphenetol will serve as an example—



In the aliphatic division, therefore, only *normal* compounds are eligible; while in the aromatic series, all but *para* substituted compounds are excluded. Bending of the chain such as would be given by an ortho- or meta-compound, or the branching produced by substitution, at once dispels all appearance of liquo-crystallinity.

BEARING UPON THE PROBLEM OF LIFE.

Striking similarities have recently been observed between the behavior of "liquid-crystals" and that of the lowest living organisms. Under certain circumstances, the droplets line up in a chain resembling long fine hairs, which afford a most realistic serpentine movement. This is trikingly shown in Fig. 7, where the "apparently living crystals" of para-azoxy cinnamic acid ethyl ester have been photographed in natural light. In spite of the very short time of exposure (one fiftieth second), the indistinctness of some of the bends clearly indicates that even during this time, considerable undulations of the serpentine folds had taken place.

Add to this curious behavior the well-known facts that crystals grow and exhibit a certain recuperative power, also that phenomena akin to auto-division and copulation are frequently to be observed among the globules of crystalline liquids, and the resemblance to the behavior of the lower forms of life becomes still more complete.

To assert, however, as Lehmann has done, that living growth depends essentially upon the agency of crystallization, is a conclusion to which all would not care to accompany him. Notwithstanding the array of evidence which he brings forward, much more research and rational consideration are necessary before anything definite can be confidently submitted. As a tentative suggestion, nevertheless, the idea is a striking one and affords an interesting contribution to modern speculation upon the origin and mechanism of life.

CONCLUSION.

The now acknowledged existence of liquo-crystalline types naturally strikes a blow at our definition of the word "crystal." Hitherto, the term has always been associated with the ideas of rigidity and solidity; but in the light of the evidence above-mentioned, this old idea must be abandoned and one must admit that under certain conditions, a *liquid* may exhibit, if not always the accidental circumstance of form, at least the more important optical properties which are the outcome of a molecular arrangement. In this way, the barrier between the solid and liquid states is partially demolished.

As to what constitutes the *raison-d'être* of liquid-crystals, the hypothesis advanced by Lehmann appears to be the most likely. Especially is this the case after the failure of the ordinary theory, which attempted an explanation on the basis of a simple emulsion. Lehmann assumes the existence of some directive force, called a "configuration-determining" force, which produces a parallel arrangement of the molecules in spite of the liquid state, and each molecule of the liquid, by virtue of this force, is supposed to be striving to arrange itself as part of a spatial configuration. Vorländer's independent observations lend considerable color to this notion. If, as he declares, all "liquid-crystal" molecules possess long chain formulæ, their shape may be taken to approximate to wires or plates and these will be able to arrange themselves in some definite order. On the other hand, with molecules not so shaped, the space they occupy approximates more nearly to the spherical, and so the liquid, being only a chance aggregation of individuals, will appear isotropic. This probably explains why it is that all liquids do not display crystallinity, though their molecules may be subject to this "configuration-determining" force.

To say more of Lehmann's brilliant achievements, both experimental and theoretical, is not possible within the narrow limits of this article. But from what has been written, it will be gathered that his work constitutes a noteworthy extension of our knowledge of states of matter, particularly of the borderland between the solid and liquid states; and from the many developments which have accrued, the whole subject should be one of surpassing interest, not only to the physicist and the crystallographer, but also to the student of chemistry or of biology.

In conclusion, the author wishes to tender his best thanks to Prof. Lehmann himself for the kindness he has shown in specially preparing the photographs which illustrate this article. Readers further interested in the subject are referred to Prof. Lehmann's numerous published researches and to his books upon the subject, the chief of which, "Flüssige Kristalle" and "Die neue Welt der flüssigen Kristalle," are well worth consideration.

Cheap Alcohol for German Manufacturers of Artificial Silk

THE German manufacturers of artificial silk have obtained a valuable concession from the *Berliner Spiritus-Zentrale* for the season of 1912-1913. According to an arrangement the average price of industrial alcohol to the manufacturers of artificial silk will be about the same as that which their foreign competitors have to pay. This may enable the German makers of nitrocellulose artificial silk to compete more successfully with imported goods.

Almost from the beginning of the industry the makers of silk by the "nitro" process have been severely handicapped by the high prices of industrial alcohol, and their repeated efforts to obtain a reduction have been quite unsuccessful for nearly seven years. The intervention of the Government and a good potato crop in Germany helped to bring about the desired result which is the cause of much satisfaction in German manufacturing circles.—*The Chemical World.*

War and the Survival of the Fittest—III*

Does Physical Conflict Between the Nations Select the Highest Type?

By Robert M. Dickie

Concluded from Scientific American Supplement No. 1932, Page 30, January 11, 1913

But is not war a test of civilization? Ritchie in his "Social Studies" has announced the theory that modern wars are really in the last analysis conflicts between different types of civilization, or civilization at different stages of development in which the superior type is assured of victory. Thus war, if it does not subvert an inferior civilization, discredits it by branding it with the mark of inferiority. On the other hand, the superior civilization is exalted and glorified by victory. By this process the cause of civilization is said to be advanced.

In considering this argument we shall see that types of civilization are difficult of definition. If, however, we make the definition of type sufficiently simple to make every variation a different type, then we may admit that whenever two nations do meet in battle, it is a clash between two types of civilization or civilizations at different stages of development, at least, so far as civilizations can be articulated on the field of battle. It is, however, a different thing to say that these differences in civilization lead to war. To establish such a proposition would be difficult indeed when we remember that modern wars have been caused by a disturbance of the balance of war, by competition for markets, by the lust of imperialism and questions of national honor, all of which are not vitally connected with differences of civilization.

Granted, however, that, no matter what may have led to the war between two nations, they are actually different types of civilization, is the Court of War competent to give a fair verdict? It is quite true that war does retard, and in a measure discredit in the eyes of the world the civilization of the defeated nation; but can the merits of two types of civilization be decided upon the field of battle? Is fighting force the criterion of civilization? If such is not the case, then war may depreciate the superior type and exalt the inferior. In war the nation wins which is superior in fighting force, but the question which is to be decided is whether or not superiority of fighting power is determined by superiority of civilization. It is common enough for the defenders of the war idea to make such assertions, but a more careful examination of the factors which go to the determination of the issues of war reveal some which are quite independent of the character of the nation's civilization.

First, there are the natural conditions of the territory of the contending nations. A nation with a compact territory abounding in strong natural fortifications and defences has an immense advantage over another nation whose territory is scattered and without such natural advantages of warfare. But such advantages may be on the side of the evidently inferior civilization. The compact character of Russian territory is a great advantage for purposes of warfare over the scattered territory of Britain.

Again, one nation may have a great advantage over another from the character of its economic conditions. The very life of one nation may depend upon its maintenance of foreign commercial relations, and these being cut off it must soon give up, if it cannot win a speedy and decisive victory. Another depending less upon its foreign trade may be able to withstand the interruption of such trade for years. Granted that in the American Civil War the superior type of civilization did win—the civilization founded upon free labor over that founded upon slavery—yet it is evident that quite apart from their respective types of civilization the North had an immense advantage over the South in its economic conditions. The life of the South depended upon its export cotton trade, which was put an end to by the blockade of its ports. This meant the entire reorganization of the conomic conditions of the South if it were to live. Whole States devoted to cotton growing were simply valueless to the Confederacy from an economic point of view. The North, on the other hand, was so situated with respect to economic conditions that a blockade of its ports, had the Confederacy been able to effect it, would have made a much smaller drain upon its strength. But such an immense advantage was in no way due to a superiority of civilization. If it be said that the economic disadvantage of the South was to be traced to slavery, it only needs to be said by way of reply that cotton growing for European markets is to this day a staple industry of the Southern States even when slavery has been abolished.

The size of the nation has not a little to do with deciding a conflict. If other things are equal, a nation of twenty millions can put twice as many men in the field as a nation of ten millions, and big battalions have always been considered one of the determining factors in war. But is bigness a criterion of civilization? Shall we say that the civilization of Russia is superior to that of Switzerland, or the type of life represented by Philip and Alva superior to that represented by William the Silent? When we remember the part played by little nations in the advancement of civilization we may be glad that in the course of history civilization has not been left to the mercy of the trampling battalions of armed hosts.

But the most important consideration of all with respect to war as a test of civilization is the fact that different types of civilization cannot always be expressed in terms of war as a common denominator. If all nations that ever do come into conflict accepted the military ideal as the first expression of national life, and if, under the guidance of this ideal, they all maintained their national life at the highest point of military efficiency, then, other things being equal, the highest type of civilization would be able to produce the most efficient national fighting force. But all nations are not under the dominion of this ideal to the same extent. There are in this respect two distinct types of national life, the military and the industrial. The one is devoted to the arts of war and aims at the best possible preparation for war at all times. The temper of the people, their traditions and ideals and their form of social organization are all adapted to this end. The other is devoted to the arts of peace; they have a genius for commerce and having at the same time a turn for idealism sufficient to give them confidence in a national policy of fair play and peace, the energy of the nation is devoted to the development of trade and commerce, education, social reform and such other enterprises as come within the purposes of a peaceful people. The national taste and temper is not conducive to military enterprises. Of course, we do not find perfect representatives of either type, but it is easy to find approximations, e. g., Switzerland and Holland approaching the industrial type, and Russia approaching the military type. The military type is always prepared for war to the utmost of its ability, the industrial type rarely is; and preparedness quite apart from staying power is a great advantage in war.

Of course a nation so entirely dominated by the military ideal that its commerce and natural resources remained undeveloped and its masses downtrodden and exploited for military purposes would soon prove inefficient for purposes of war. Its administration would likely become corrupt, its exchequer exhausted and its people lacking in character. The nation bent on military efficiency will see to the character of its people, for serfs and slaves never yet fought as citizens, and to its exchequer, for the most splendid army needs rations and war is the most expensive of all national enterprises. It will look to all influences that shape the character of its citizens and add to the material wealth of the nation, for these have much to do with its military efficiency. If there be added to this the highest degree of militarism compatible with it then we have a nation at its highest point of fighting efficiency.

But nations otherwise equal may differ widely in the degree of their military preparations for war. Germany, France and Russia are apparently carrying their utmost while Holland, Switzerland and Norway are carrying comparatively little. Suppose these nations were in other respects equal, there is no doubt but the best armed and most prepared nation would have an immense advantage in war. Let us take an actual case, that of the threatened war between Britain and the United States over the Venezuela boundary in 1892. One would say there was no great disparity between the characters of these peoples or their material resources; but Britain certainly had a great advantage in her degree of military preparedness. On the one side was a navy equal to any other two of the world's navies, and on the other was the mere nucleus of a navy that might in twenty years become respectable. This disparity in preparedness for war was due first to the different situations geographically and economically of the two nations in question, which surely had nothing to do with the character of their civilization; and in the second place to the difference of the two nations in their liking for militarism and belief in it. This latter feature, state it as we may, is more marked in some nations than in others. As some men are by nature more pugnacious and have more faith in force than others, so some nations by temper are more warlike and have more faith in militarism than others. But because one nation maintains itself at the highest possible degree of military efficiency and preparedness, is this an evidence of its superiority of type over that of nations whose immediate military efficiency and preparedness is far from the standard which it might maintain were it a little more possessed of the military spirit? If it were certain that both nations had to fight for their existence, then to be unprepared would be an evidence of the kind of stupidity that the "Army and Navy Club" charge against the people of Britain. But to assert that a nation must fight in order to live is to beg the question. That remains to be seen. If it is asserted that the superiority of civilization is evidenced by the accuracy with which a nation forsees a coming conflict, it may be replied that the causes of war are not always discernible. The Venezuela boundary trouble could not be forseen by the United States as the conflict with Russia was forseen by the Japanese. Moreover, any extraordinary strengthening of military power may precipitate a war, as witness the German war panic of two years ago. Preparedness for war is, in a measure at any rate, determined by factors which are not necessarily criteria of civilization—faith in force, the military spirit, exigencies of domestic and world politics, international relationship, etc.

It may be granted that the civilization of a nation counts very much in war; commercial, educational and political development and organization all make for efficiency of national fighting force. There are, however, many features of civilization and these among the highest and most worthy which cannot be expressed in terms of war and consequently cannot help a nation on the battlefield, no matter how highly developed they may be. This is particularly true of art. Napoleon stabling his horses in a room on a wall of which was painted Leonardo de Vinci's "Last Supper" is evidence of the poverty of the contribution art can make to the fighting efficiency of a nation. The only poetry and music which serves the ends of war is that of the jingo and music hall variety. If Shakespeare and Goethe and Tolstoi have made any contribution to the civilization of their respective countries it was not such as could be expressed in terms of war.

Again, it is very difficult to define the different types of national civilization because of the ever-increasing stratification of society, due largely to world movements and organizations. University life at Heidelberg, Oxford, Harvard and Moscow has much in common. A student from one would find himself much more at home, in point of taste, temper and view-point, at any of the others than in many social circles in his own land. The trader whose business outlook takes him beyond his own nation is not so much stranger among traders of other countries who operate in a wide field as in the company of government officials of his own country. The socialist and trades-unionist of one nation is on the friendliest terms with his brother in another nation and understands him, while he does not like and perhaps does not understand the capitalist of his own. They represent different types. This stratification of society works two ways. In the first place it shows us a variety of types in each nation, and in the second place it shows us that these types are found in other nations.

As a matter of fact, we usually judge of the national life by that which controls the government, since it dictates the national policy. But this type does not always adequately represent the life of the nation. In the case of Germany, for instance, the Emperor with the support of the militarists and Prussian junkers control the government, but the great and growing body of social-democrats have ideals of national life of quite another type, though they are as yet powerless to express them in national policy. But nothing is more certain than that if they continue to develop in strength as they have in the past twenty years they will control the national policy of Germany. Even now it is a question if they do not more adequately express the spirit and ideals of the great body of the people than do those in power. At any rate when such diverse types exist within a nation and when they are each represented in other countries it is difficult to see how the victory of one nation over another exalts the type of civilization represented by the victor.

One thing, however, usually happens among these various types within a nation through war—a war always means the exaltation and strengthening of the military type. This has been so well understood by arbitrary rulers, that from time immemorial it has been recognized that to engage the attention of a people in war is a most efficient way of turning their minds from much needed social reforms at home. A German war would undoubtedly set back the cause of social democracy in that nation and prolong the present type of national policy. The school of Gen. Homer Lea got its footing in the American

* Reproduced from *Queens Quarterly*

commonwealth after the Spanish war. The Boer war no doubt sowed the seeds of militarism in the younger nations of the British empire which have brought forth our tin-pot navies.

To sum up our answer to the contention that war is a test of civilization in which the superior type is strengthened and exalted: we have granted that civilization has much to do in deciding a war between nations, but we have pointed out that other factors enter into his trial by force. The size of the nation, its geographical features, its economic conditions all contribute towards the issue of a war and these may as likely be on the side of the inferior civilization as on that of the superior, bribing, as it were, the court of war. Besides this, nations differ in respect of martial spirit and faith in force which makes a great disparity in their preparedness for war, and military preparedness is among the most effective forces in a conflict of arms, but it cannot be claimed that the type of civilization thus unprepared is in any way inferior. Moreover, it is difficult when we remember the stratification of society to differentiate types of national life. Each nation embraces different types and the general effect of war is to exalt and strengthen the military type at the expense of the others.

IV.

May we not go a step farther and ask, if war does not select the superior type, does it not actually impede the only rational process of selection among various types of civilization? Conflict is indeed the condition of progress, but there are other conflicts than those of force. There is such a thing as a conflict of ideas: new ideas are ever at war with old and in the long run the fit survive, i. e., those which best cohere with the body of accepted truth. Views, theories, hypotheses, philosophies are ever engaged in a struggle for existence; Berkeley struggles with Locke and Kant with Hume. The fittest under the circumstances and as a whole survive. Only it is not a process of natural selection as in the lower orders of life where organism struggles with organism and environment, but a process of rational selection in which thoughts struggle one with another in being adapted to a great body of accepted truth. The one is natural since it proceeds on the plane of natural forces, the other is rational since it proceeds on the plane of intellect and idea. In one case it is a conflict of physical force, in which of course intelligent direction counts much, whereas physical force does not, and in the nature of things cannot, enter into the other.

Let us suppose that two philosophers representing conflicting schools of thought coming together—and so far as we know ideas can never come into conflict except through the media of human organisms—and each presenting his views to the other. If they had time enough and patience enough and sufficient of the friendly mind there would be a real process of rational selection in which the true view would prevail. Even with much less time and patience either or both views might be considerably modified as a result. But they are men as well as philosophers and suppose that in the course of their argumentation their prejudices and passions became so inflamed that they forgot themselves and took off their coats and fell to fighting. There would be other results than bruises and flushed faces; for our purposes the chief of these would be a sudden stop to the process of rational selection that was proceeding so favorably. Hate and bitterness would confirm each philosopher in his own views and close the doors of his mind against the views of the other, and not only would this be true of the symposium in question, but very likely of all future symposiums. Probably each would find it difficult to bring a friendly mind to the consideration of the views held by the other, no matter who expounded them, for philosophers are still men and thinkers are organisms. In such an unfortunate experience we have a process of rational selection being interrupted by a process of natural selection. It would be difficult to find a philosopher, be he ever so skilled in giving good reasons for bad causes, who would defend the result of this conflict of force as a vindication of a superior philosophy.

Now the soul of civilization is in idea and ideal entertained by a people and in some measure articulated in their common life. It is impossible to define it in the totality of its expressions. It does however include the scientific knowledge of the people and its application to life, their methods of production and exchange expressed in their commercial institutions, their social and educational ideals expressed in their appropriate institutions and their larger views of life and the universe expressed in their philosophy and religion. If we could have a sort of composite photograph of these features of a nation's life it might be taken as a very fair representation of its civilization. In each of those features it will be noted that it is a matter of ideal and method of life; that is, the conceived and accepted ends of life together with methods by which their realization is attempted. These include the essential features of a civilization. Now in the case of both ideals and methods a process of rational selection naturally proceeds. There is only one way in which one ideal of life may be proved superior to another, and that is by showing that its realization would bring more satisfaction to life than the realization of the other, or that in it life can better realize itself than in the other. But how can this be determined except by reflexion sufficient to give presumptive evidence that one will give more satisfaction than another and then by actual experiment? The two must be reflected upon and judged by impartial minds, and in the long run people will choose what gives them most satisfaction. Whatever closes the mind against one ideal or prejudices the mind against it either puts this ideal out of the process of rational selection or so far handicaps it. This is what passion and strife always do; and war means national passion and strife. Suppose two nations living side by side, entertaining different ideals, say of government, one the ideal of democracy, the other the ideal of aristocracy. Should they live together long enough in friendly intercourse so as to become familiar each with the other's ideal and marked the degree of satisfaction which each derived from the measure of its realization, one ideal would profoundly modify the other, and if other things were equal their ideals of government would continue to approximate each other until at last they became identical. One ideal would not necessarily push the other out of the field, in all probability one would modify the other until the final ideal would be such as could not be adequately characterized as either democracy or aristocracy. But, suppose these two nations are led into war through a conflict of interests arising out of the diversity of their governmental ideals, how would this affect the process of rational selection which is naturally proceeding? It would immediately cease just as truly as the argumentation of the philosophers when they took to fisticuffs. The ideal conflict would give place to the physical. The heat and passion of war blinds the eyes of a nation so that it cannot appreciate the worth of its antagonist's ideals. Not only so, but just in proportion as the conflict has arisen through these conflicting ideals the one nation will keep its mind closed against the ideal of the other long after the physical struggle is over. Free intercourse and a friendly mind are always necessary to the process of rational selection among national ideals, and both of these are impossible when there is an appeal to the arbitrament of the sword.

It is not necessary to speak at length upon questions of method by which nations endeavor to realize their ideals and which are features of their peculiar civilizations. Here likewise a process of rational selection proceeds under favorable circumstances, the chief of which are free intercourse and a friendly mind. Efficiency of method is keenly scrutinized where there is a common ideal, and the most efficient speedily adopted when it is demonstrated to be such. But even in the case of methods war seriously hinders the process by blinding a people's eyes to the merits of their enemies' methods and by keeping a knowledge of such methods from them, the former by failure to appreciate through hate, the latter by ignorance through national isolation.

In answering the question, does war decide the superior type of civilization, we must then bear in mind the difference between natural and rational selection, the one operating in the field of natural forces, the other in the field of ideas and ideals. And since the soul of civilization is in idea and ideal the only true process of selection among different types is the rational. The prime condition of such a process of selection is the open mind on the part of each and friendly intercourse between them. Only when they are brought together and surveyed with impartial and dispassionate eyes can one be said to gain the ascendancy over the other. But this is what war makes impossible. It separates peoples of different types, it interrupts friendly intercourse, and above all it sows the seeds of hate and bitterness and distrust which make impartial and rational competition impossible. Instead then of saying that war is a conflict of civilization in which the fit is perpetuated, it seems truer to say that it is the greatest known hindrance to any such conflict.

Gambia Mahogany

The more intensively the forest flora of East Africa is investigated, the larger becomes the list of genera and species, which have been known heretofore as native only to tropical West Africa. This list includes a number of important forest trees, which extend from the Atlantic to the Indian Ocean. Gambia or African mahogany (*Khaya senegalensis*, Juss.) is perhaps the most important one that has this extensive range of growth. It is found in the forests bordering Mombo River and along the caravan route which leads from Tanga to Masinde in German East Africa. Here the tree associates with several species of *Parkia*, *Pterygota* and *Ficus*. This tree, which is very important commercially, is more abundant in West Africa, where it has been exploited for over twenty-five years. Its timber has been one of the chief sources of revenue for Sierra Leone, Lagos, Kamerun, Angola and parts of Congo. The tree is found also in the upper Nile region, especially in the sections known as Djur and Nyssaland, but it is rare at this distance from the coast. According to authentic references in botanical literature, this tree is very common in the neighborhood of Cape Verde and along the Gambia River, where it is called Gambia mahogany by the English colonists. In the French provinces the tree is known as cail or cail-cedro. The negroes of West Africa have named it "hie," "jallow," "dubina," and "oganwo."

The first observations in regard to the distribution of this tree were made by Guillemin and Perrottet in their "Flora Senegambia." In this work they state that Gambia mahogany is among the largest and most beautiful trees along the coast of Gambia and on elevated parts of Cape Verde peninsula. It is very abundant in the district of Bargny, where it forms the principal stand of the forests. In Senegal this tree is now being planted on a commercial scale by the French, because it produces a very valuable wood, which has attained considerable importance in the trade. Upon the whole there is scarcely a tree in West Africa which deserves more attention; for, when the beauty and usefulness of its wood are taken into account, there is no other tree that can compare with it.

African mahogany is a name given to a good many other woods that are now being cut and sold, but the name "Gambia" mahogany is applied only to the wood of *Khaya senegalensis*, which is prized beyond all others as a substitute for the genuine mahogany (*Swietenia mahagoni*, Jacq.). Gambia mahogany is a large and very beautiful tree and yields one of the most abundant and useful timbers. It frequently attains a height of over 100 feet and an average trunk diameter above the enormous buttresses of over 3 feet. The tree is usually perfectly straight, so that splendid and most valuable boards may be cut from the logs. The wood is best suited for carpentry and cabinet work, and is used extensively for making handsome and expensive furniture. In color and figure it often resembles the true mahogany of tropical America, but it is somewhat softer, paler, slightly coarser, and is more liable to check in seasoning. The natives make boats of great strength and durability out of single logs of this tree. The tree yields a gum which was formerly collected and exported as a substitute for gum arabic.

The West African mahogany trade began in 1886, and the industry has attained such proportions that the output of tropical American mahogany has not increased in spite of the fact that there has been an enormous enlargement in the use of so-called mahogany. African kinds are shipped into the United States in large quantities, and the best grades are cheaper than similar grades of the true mahogany from Cuba or Mexico. The wood is somewhat paler red and works with greater difficulty than the tropical American mahogany, and is less valuable on this account. Since the tree is so widely distributed and the wood procurable in such large quantities and at so many ports along the west coast of Africa, it has come into extensive use both in Europe and in America. Some of the logs are beautifully figured and the wood is highly esteemed for the best grades of furniture.

It is difficult to predict what the prospects for the Gambia mahogany will be in West Africa in ten years from now. The supply seems almost inexhaustible, but it is more than likely that the easily accessible trees will soon be cut and inferior substitutes will take its place. No less than twenty other species, most of them entirely unrelated, are now being exploited and shipped to the large markets under the name of African mahogany. Many of them are very good woods, but all of these imitations now sold under the comprehensive trade name of African mahogany are deficient in some of the estimable qualities which characterize the original African or Gambia mahogany.

It is practically impossible to secure accurate statistics as the kinds and amounts exported from the various shipping points. That the industry as a whole is increasing is chiefly noticeable from the figures of imports of so-called African mahogany into this country. Out of the total quantity of true and substitute mahoganies imported during 1910, which was 44,524,000 board feet, about 19,000,000 feet were African substitutes.

Quantity and Value of True and Substitute Mahoganies (Unsawed) Imported from 1901–1910.

Year.	Quantity—M. feet.	Value.
1901	32,281	$1,752,612
1902	44,795	2,361,483
1903	48,387	2,783,679
1904	50,370	2,690,382
1905	31,844	1,977,894
1906	36,619	2,470,072
1907	51,899	3,263,718
1908	41,678	2,566,954
1909	39,828	2,479,976
1910	44,524	3,224,152

The Etrich Monoplanes

Description of Several of the Latest Aeroplanes of the Austrian Pioneer

By Stanley Yale Beach

The Etrich monoplane has perhaps one of the most original wing designs among all machines successfully flown. The ribs are made very flexible at their rear ends, and the wing tips extend back beyond the rear edge of the main plane a considerable distance.

The extremely pliable rear edge of the supporting surface gives under a sudden wind puff, and the equilibrium of the machine is not upset as when a rigid plane is used. The backwardly-extending pliable wing tips still further add to the transverse and longitudinal stability. On the latest Etrich machines these rear wing tips are up-curved normally. The front edge of the wing is also curved slightly upward at the end of the wing, the result being that if the machine starts to dive the pressure on the top of the up-curved rear tip of the wing and beneath the up-curved front edge, tends to check the dive and to right the monoplane. This machine is well balanced, all movable weight being confined to a section a foot or two in width (fore-and-aft) at about the center of the wings. As a result of the above points, the Etrich monoplane has great fore-and-aft as well as transverse stability.

The guiding of this monoplane in a vertical plane is made doubly sure by a long, broad tail, about half of which is flexed upward and downward to elevate or depress the nose of the machine. Triangular vertical rudders of small dimensions are fitted above and below this elevator.

The machine shown in the large picture at the bottom of our front page is the military Etrich monoplane, known as the "Taube" ("Pigeon") type. One of these machines has recently been purchased by the British war office, and the German war department has thirty of them, built in that country by Rumpler. As can be seen from the photograph, this machine has a triangular body. A 60 horse-power four-cylinder, Austro-Daimler water-cooled motor is mounted in the boat-like bow and carries a 6-foot 9-inch "Integrale" propeller on the front end of its crankshaft. The propeller runs at 1,300 revolutions per minute. An A-shaped radiator is mounted against the shear legs which support the guys and which are placed over the rear of the passenger's seat. This seat is directly back of the motor and is separated from it by a curved hood. The aviator's seat is behind the passenger's and is separated from it by a similar hood.

The wings are guyed below to the chassis by a number of cables and are reinforced by a bridge truss of light weight steel tubing to the end king posts of which, projecting above the wings, run up six or eight guys to aid in supporting the wings. A small wheel is placed on the bottom of each end king post. The wings are built up on three main spars. The flexible trailing edge is obtained by means of bamboo strips, which are spliced to the ribs. Nearly half of the breadth of the wing is warped, together with the rearwardly extending tips.

The German aviator Hirth's racing "Pigeon" has a spread of 12.04 meters (39.5 feet), an over-all length of 9.52 meters (31.23 feet), and a height of 2.78 meters (9.12 feet). The chord of the wing is 2.34 meters (7.67 feet) at the body, and the width of the tail is 2.8 meters (9.18 feet).

A second successful type of Etrich monoplane is the "Swallow," shown in one of our illustrations, as well as in plan and elevation, on this page. This machine has wings curved backward, like those of a swallow, the wings being flexible at their rear edges. Although the wings and tail have been shaped as nearly as possible like those of the swallow, the "Zanonia" form, which is patterned after the blades of the small herb of this name, is still made use of, as can be seen by the negative angle of incidence of the wing tips. There is a decided change in angle from the body out toward the tip. Near the body the wings have a decided camber and an angle of incidence of about 5 degrees, while at the tips they are turned upward so that a distinct negative angle is produced. This machine is built largely of steel tubing, the fuselage being made up of wooden rings fastened to the long tubes and the whole being covered with fabric. The machine is a three-seater, the seats being arranged in tandem. Small celluloid windows are placed in the right-hand wing. The control consists of a vertical steering column the wheel of which is moved forward and backward to operate the elevator, and is turned to work the vertical rudder. There is no wing warping on this machine, the flexibility of the wings alone being depended upon to maintain the transverse equilibrium. In flight the machine oscillates rather rapidly about its longitudinal axis. The weight of the machine is 500 pounds. It is fitted with a 60 horse-power motor, and has been driven at well over 70 miles an hour when carrying three persons. It has fuel capacity for three hours with a full load.

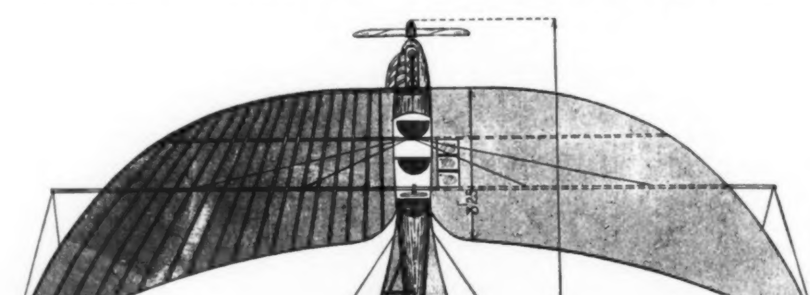
Another interesting machine is the "Limousine," shown in profile in one of our illustrations. The large fish-shaped body of this machine is built up of wooden channel section longitudinals and 12 wooden rings covered with thin sheets of aluminium in the front and with cloth in the rear. Inside the body there are four seats arranged in pairs. In front the spaces between these rings are covered with wire gauze and celluloid, in order to form windows and protect the occupants of the machine from the wind. The motor is placed high up in the bow, and the radiator is located behind the motor as in the "Swallow" (see photograph of latter machine). The machine is provided with a change speed device, which allows of varying the pitch of the propeller when in flight. This machine has flown successfully with three passengers at Josefstadt. Its dimensions are the same as those of the "Pigeon," and the motor is of 60 horse-power.

Front of Etrich "Swallow."

Note simple undercarriage, celluloid window in wing, and automobile radiator.

Another noteworthy machine built by Etrich is the two-motor, 200 horse-power monoplane, constructed for the Russian Government. This machine has one 4-cylinder Daimler motor high up in the bow and carrying the propeller on its crankshaft, while the other 4-cylinder motor is mounted just back of the first motor, low down in the body, and drives a second propeller, mounted concentrically with the first, by means of sprockets and a chain. This second propeller is slightly smaller than the first one, and both revolve in the same direction. This machine has made excellent flights although its speed was not anything extraordinary.

The German aviator Helmuth Hirth has been flying during the last four or five months a new fast Etrich monoplane, fitted with a 95 horse-power Mercedes motor. With this machine he has won a number of the chief events of the past year, such as the upper Rhine circuit, the Berlin to Vienna race, and a circuit race the middle of October, starting at Mannheim and finishing at Munich. In this last event, out of 14 machines which started, six monoplanes, five of them Rumpler "Pigeons," were destroyed and two officers lost their lives, though not in these machines. Only three other aviators succeeded in finishing the circuit. During one stage Hirth's propeller was badly damaged by hail, and the aviator met with terrific wind gusts. Nevertheless, he made the stage of 102 miles from Frankfort to Nuremburg in an hour and fifty minutes, while Lieut. Joly on a similar machine covered this distance in two hours and six minutes, including a five-minute stop at Wurzburg. Bad weather lasted throughout this circuit, which consisted of a total distance of 515 kilometers (320 miles), and was covered by Hirth in the total time of 3 hours 51 minutes, or at the rate of 83 miles an hour. Hirth has written a very interesting book entitled "20,000 Kilometers in the Atmospheric Ocean," in which he details his experiences in flying 120,000 miles in Etrich machines.



Illustrations courtesy *Aeronautics*.

The scale of above drawing, as reproduced, is about 1:103.

Plan and Front and Side Elevation of "Swallow" Monoplane.

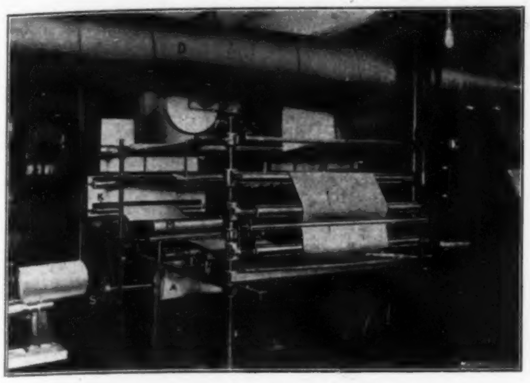


Fig. 1.—Front View of Coating Machine and Dryer for Blue Print Paper.

Blueprint Paper*

Its Manufacture and Some of Its Characteristics

By F. B. Hays

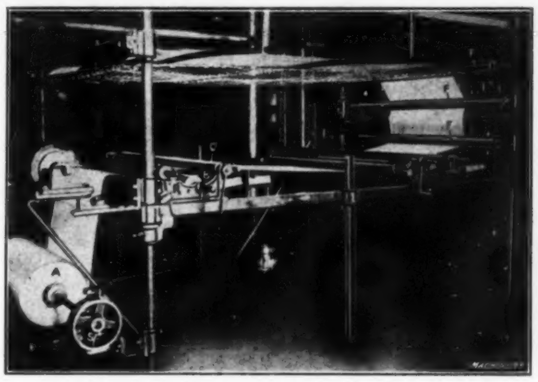


Fig. 2.—Side View of the Coating Machine and Dryer, Shown in Fig. 1.

The constantly increasing use of blueprints has caused the manufacture of blueprint paper to become an industry of considerable magnitude. The majority of people connected with engineering work has a fairly clear idea of the methods employed in making blueprints, and a few draftsmen and engineers understand the principles of coating the paper, but only a very small number have any conception of the methods and processes employed in producing large quantities of blueprint paper. The following article describes the most general methods used. The machinery illustrated in the accompanying halftones is representative of the most modern and efficient type in use.

A special kind of paper is used in making blueprint paper. The principal requisites of this paper are: First, that it be free from wood pulp and the chemical impurities that are found in cheap papers, such as newspaper stock, wrapping paper, etc.; second, that it be sufficiently tough to withstand frequent washing and rough handling; third, that it possess a fairly hard, and not too absorbent or coarse grained surface; and, fourth, that it be properly sized on that surface which is to receive the coating. The size which gives the best results is a mixture of arrowroot flour and water. The flour is first mixed with a sufficient quantity of cold water to produce a thick paste, and then from forty to fifty parts of warm water are added.

SENSITIZING SOLUTIONS.

The process of coating paper for blueprinting is termed "sensitizing," and it consists of coating the paper on one side with a solution that undergoes marked chemical changes when brought into contact with certain kinds of light and water. This process, although more or less complicated from a chemical standpoint, is very simple mechanically, provided only small quantities of paper are to be sensitized, but when done on a large scale special machinery and very skillful handling are required.

One of the oldest and most popular formulæ for sensitizing paper that will print white lines on a blue background is: (*A*) Ammonia-citrate of iron, 20 parts; water, 100 parts. (*B*) Potassium ferricyanide, 16 parts; water, 100 parts. The sensitizing solution is made by mixing equal parts of (*A*) and (*B*) together, and filtering just before using. Another solution which gives good results, and which may be kept on hand for several months without deteriorating, is the following: (*A*) Ammonia-citrate of iron, 12 parts; water, 16 parts. (*B*) Potassium ferricyanide, 9 parts; water, 16 ounces. Mix together and filter one part each of (*A*) and (*B*), and add two parts of water just before using.

For coarse-grained, rough-surfaced papers, and silk and linen cloth, an excellent solution is obtained by the use of gum arabic. (*A*) Pulverized gum arabic, 1 part, dissolved in 20 parts water, and strained through muslin, combined with ammonia-citrate of iron, 5 parts. (*B*) Potassium ferricyanide, 4 parts, water, 20 parts. Equal parts of (*A*) and (*B*) are mixed before using. Fabrics must be washed and then sized in gelatine (hard gelatine dissolved in twenty parts water) before sensitizing.

* Reproduced from *Machinery*.

Positive paper, or that which gives a blue line on a white background is produced in the same manner as negative paper, except that it is sensitized with different solutions. A number of mixtures may be used, but the two following are probably the most popular:

1. Oxalic acid, 1 part; iron perchloride, 2 parts; water, 20 parts.

2. (*A*) Powdered gum arabic, 2 parts; water, 10 parts. (*B*) Ammonia-citrate of iron, 2 parts; water. 4 parts. (*C*) Chloride of iron. 1 part; water, 2 parts. First dissolve the gum and strain the solution (*A*) through muslin; add solution (*B*) to solution (*A*), stirring well; finally add solution (*C*) to the mixture of (*A*) and (*B*). This solution must be kept for twenty-four hours in the dark and must be frequently agitated before using.

Paper which produces positive black lines on a white background is sensitized and then developed. The sensitizing is a solution consisting of ferro sulphate, 20 parts; ferric chloride, 45 parts; tartaric acid, 40 parts; water, 190 parts. The developing solution is a mixture of gallic acid, 15 parts; oxalic acid, 2 parts; water, 1,700 parts. After developing, the prints are washed in running water.

In mixing any of the foregoing solutions, only distilled water should be used, and all operations should be carried out in a red or orange light.

SENSITIZING THE PAPER.

The coating of the paper with the sensitizing solutions and the subsequent drying and rolling is now done entirely by machinery. Fig. 1 shows a general view of a machine for this purpose. The coating machine is shown toward the front and the drier in the background. The driving mechanisms is shown on the floor in front of the machine. The air for the drier is received from a purifier and forced through pipe (*D*) and heater (*E*) into the drying oven. The general operation of the machine is as follows: The sized paper starts from the roll (*A*), Figs 1 and 2, and passes between two pulling rollers and over the celluloid coating roller (*B*), Fig. 2. This roller is partially submerged in the coating solution placed in tank (*R*), and as it revolves it carries a small film of the solution, which is absorbed by the lower surface of the paper. A glass bar runs along the edge of the tank, and a roller (*C*) presses the paper against this bar so that all excess solution is wiped from its surface and returns to the tank. This latter roller also regulates the pressure between the paper and the coating roller (*B*). The bearings for roller (*C*) are placed in a rocker arm, so that it may be raised or lowered by means of a crank, thus decreasing or increasing the tension on the paper. Another retaining tank and a similar series of rollers is shown at the other end of the machine, and serve to administer the second coat of the solution. The rollers (*F*) are simply guide rollers, and the tubes above the machine prevent the paper from sagging and becoming strained between the guide rollers. All of the rollers are made of brass, except the coating roller which is made of celluloid, and are mounted upon ball bearings. They are driven from the main shaft by gears proportioned to impart the same lineal speed to each roll.

At (*S*), Fig. 2, is shown a band brake which regulates the tension of the paper and also prevents it from unrolling from the spools when the machine is stopped. Upon leaving the coating machine the paper immediately enters the drier, where it runs upon rollers along the upper part of the drier to the extreme end, and returns upon rollers on the lower side, leaving at (*K*) and being wound upon the spool (*M*), Fig. 1. Both the top and bottom of the drier are covered with steam coils, and the hot air forced into it thoroughly dries the sensitized paper before it is wound upon the spool (*M*). The moist air is removed from the drier by a pipe at the back which terminates at an exhaust fan on the outside of the building.

As it is necessary to keep the colored windows of this department closed because of the injurious effects of daylight upon the finished paper and the sensitizing solutions, air is artificially supplied by blowers and exhaust fans.

When the rolls of sensitized paper are removed from the coating and drying machines (each of which has a capacity of 1,500 yards an hour), they are taken to the re-rolling and measuring machine shown in Fig. 3, where they are re-rolled into packages of desired length for the market. This machine consists of a "rolling" shaft (*A*) having a universal joint and driven through a friction clutch at the left from the motor beneath the machine; the clutch is controlled by a foot pedal. The operation of the machine is as follows: The operator places one of the large rolls of paper from the drier on the shaft at the back of the machine and starts it upon the "rolling" shaft (*A*) by means of the handwheel. This wheel has a jaw clutch connection with the shaft, so that it can be slipped out of connection with the shaft as soon as the paper is started, and the shaft driven by power through the clutch. As the paper passes over the table of the machine the registering device shown records the number of yards re-rolled, so that the operator simply has to throw out the clutch and cut off the paper when the package has reached the proper size. The shaft (*A*) is then swung out on its universal joint and the roll slid off and sent to the packing department, where it is wrapped in light-proof paper and sealed up ready for the market.

Frequently orders for large quantities of short lengths of paper are received, and are handled by means of the mechanism shown in Fig. 4. This consists of four shafts, each inserted into a roll of paper, and supported by a steel plate on each end; a polished steel guide (*A*); a steel I-beam support (*F*), which is finished on the top and upper edges; two ball bearings (*D*); a hardened tool steel cutter (*E*); a handle (*C*); and a body casting (*B*). The paper is pulled from the rolls in four layers (one from each roll) and measured by means of a steel scale (*G*) on the edge of the table. The operator then pushes the cutter across the paper by means of the handle (*C*), the ball bearings holding the paper rigidily in place while the cutter shears it off. The top of the beam (*F*) acts as a cutting table, and the finished edge serves as a

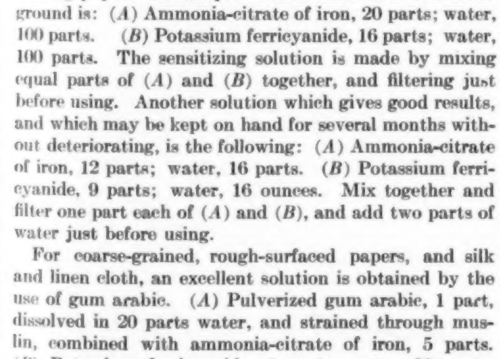


Fig. 3.—Measuring Machine for Blueprint Paper.

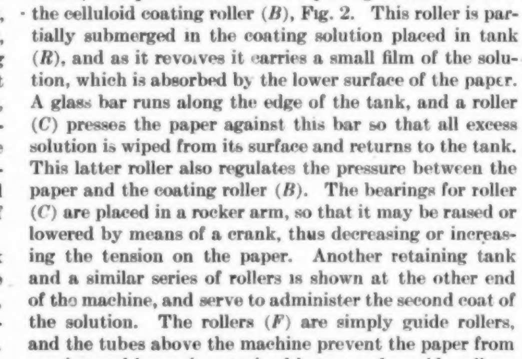


Fig. 4.—A "Cutting-off" Machine.

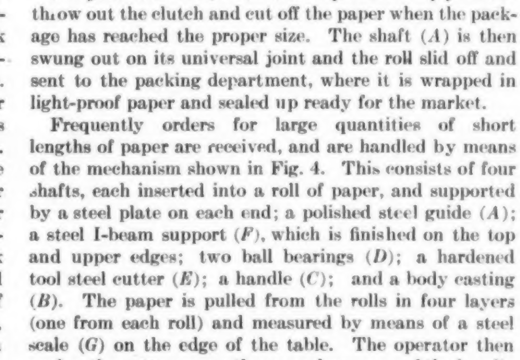


Fig. 5.—Solutions are Kept in Light-proof Receptacles.

sharpener for the circular cutter. Five hundred and eighty yard lengths of paper an hour are cut by this device. It is especially successful in handling tracing cloth and drawing paper.

The principles involved in the chemistry of sensitizing paper for blueprinting were first discovered about 1725, but were not practically applied until 1835 when an English scientist, Sir John Herschel, developed the ferro-prussiate process, which is still used at the present day and which serves as a basis for all other blueprinting methods. Many new branches of industry have arisen since 1835, and practically all the methods of the old industries have been greatly changed and improved, but the principal chemical processes of making blue prints are virtually the same now as they were twenty-seven years ago. Great strides have been made in the mechanical methods of making, coating, and printing blueprint paper, but no improved simple and efficient chemical process has been developed for producing sensitizing solutions, or for incorporating them with the fabrics. What we need at the present time is a cheap, reliable, quick printing paper that will require neither developing nor washing after printing, and that will withstand rough usage and not fade a short time after printing. It seems reasonable to believe that such a paper could be produced at the paper mills by incorporating the sensitizer with the primer, provided a suitable sensitizing solution were discovered. Far more wonderful developments than this have been made in the chemistry of photography, but for some reason chemists seem to have entirely overlooked its sister subject, blueprinting. Let us hope that in the near future chemists will turn their attention to this matter, and that the chemical side of blueprinting, this neglected branch of the science of photography, will be greatly simplified and improved.

Considerations on the Nature of Intellectual Property

Observations Made Thirty-five Years Ago By the Late Professor N. S. Shaler

[The present agitation for a revision of our patent system is nothing new in the history of American legislation. In 1877 an attempt was made to inject into the American patent system, some of the doctrines advocated by Congressman Oldfield in his bill. The late Prof. N. S. Shaler of Harvard University published a very remarkable analysis of the nature of intellectual property in 1878 directed against the measure then proposed. His arguments are as valid now as they were then. Accordingly, we present them here for the benefit of those who have followed the present controversy. The book from which the following paragraphs are abstracted is entitled "The Nature of Intellectual Property." It was published by James I. Osgood & Co. in Boston, in 1878.—Editor.]

In the last days of the late distracted session of Congress a stealthy effort was made to push through the legislative ways a bill that would have practically abolished the limited monopoly of inventions granted by our present patent laws. . . . As this scheme has the backing of several strong corporations as well as of the proletariat spirit of a large part of the agricultural communities of the West, it is sure to be revived in the next session of the national legislature. Once again it will be said in varied ways that there is no natural property in inventions; that they are evolved, like the German's camel, from the depths of the inventor's consciousness; and the cheap and miraculous product should therefore be at the disposition of all who might desire it for their own use. It will be suggested that inventors and book-makers are, as a class, something like prophets—mere vehicles of a divine afflatus, which is naturally meant to fill all sails alike; the prophet himself being properly satisfied by the large share of honor which has, as is well known, always belonged to his ilk in his own land time, making up for any deficiencies that might arise in this mode of payment by the inward satisfaction which does so fill those who have deserved well of their race. There will be various schemes for double-acting interconvertible patents and copyrights which are to give the inventor his full due, and still leave the world at large to do as it pleases with his inventions. Cheap patents, patents for the people, bloated patent-holders, will take the places of the old war-cries whenever the representatives of toil with fixed and limited rewards find themselves together.

Although the matter of property in the results of intellectual labor, whether it be given in a book, a symphony, or a machine, is essentially the same, it will be that class of intellectual labor which is included in what are popularly called inventions that will first meet the shock of the coming assault. There the wealth is great, and the feeling that found expression in the words of Blücher, applied to the shops of London, "What a place to loot!" adds a vigor to the campaign it could not have if the copyrights were the expected plunder. Great as have been the rewards of the authors of certain books, the authors of certain machines have been paid tenfold as well. Great streams of wealth pour into the coffers of the winner of the rare prizes in this great lottery of invention. Goodyear, Colt, Bigelow, Howe, McCormack, and perhaps a score of others in this country and Europe, have been made millionnaires by their inventions, and thousands have had their reward in full though lesser share. They seem to the short-sighted to lay a tax upon every dweller in the land. He cannot realize that, so far from being taskmasters, they in truth are givers of a great dole. When he cannot wear a shoe or harvest a field without rendering them a due, it is not strange that he should consider them as tax-gatherers of doubtful title. The extensive literature of patent-law decisions shows that this view is not limited to those who are short-sighted through ignorance; there are many of some understanding that hold views with regard to this sort of property which, if applied to ordinary goods, would be regarded as rank communism.

All these propositions for a radical change in the law of patent and other author rights are based upon the most unwarranted assumption that the so-called natural right to this class of property is less strong than that to other property, such as lands or chattels; in a word, that this kind of property is in a peculiar fashion the gift of society to the possessor, and not something having property characteristics in itself. This view of the case will not stand a moment's consideration. It matters not that the acknowledgment of such possessions is a late result of the progress of law, nor that such rights can be traced back to a certain association with monopolies of salt and other flagrant abuses of olden days; the property of the individual in his own person is really a relatively recent acquisition, one that was not gained until a yesterday in our own legal system. We must ask the reader to dismiss this prejudice, arising from the relative newness of the law affecting this class of possessions. He will surely see, without argument, that rights are not reasonable nor just in proportion to their antiquity, and that the divinity that doth hedge acres or town lots is largely a prejudice arising from the fact that such property has only become established in custom. If he will now go a step farther and consider the essential nature of property, he will, we hope, see that the title to intellectual property rests upon an even higher level of right than can be assigned to any other material possession. It may be laid down as a general principle that property is divisible into two distinct classes of possessions: 1st, that which is inherent in the nature of the world about us, and 2d, that which is the result of the individual powers of men. The savage picked his bits of flint where he could find them; they became his property through the skill and labor of their fashioning. He had no property in his game until it became, as it were, marked by his arrow lodged within it. As organization advanced, the growing crops in the commonly shared lands had the fence of right built round them, and as in time agriculture became the thing of years of labor, a part of the sowing remaining, as it were, always in the improved soil, these possessions extended to the fields. On the theory that held in other lands, the whole state was the king's, and these rights were given by some form of patent, such as we now give to the highest and most difficult forms of improvement alone. Out of these principles of right, which we can only indicate, and cannot trace even in outline, grew the possessions of a simple society, the more or less absolute right to chattels, and the more or less limited right to real estate.

While life was the relatively simple thing it was in all the earlier ages, when the tools of one generation were inherited, unchanged, by the succeeding, and not kept, as they are now, in museums to be wondered at, there was no need of other forms of possessions. The additions made by inventive individuals were very limited. Scarcely anything could, in the nature of the labor system then existing, start as a great whole from the brain of one man. As learning advanced, and physical science grew to be an element in human life, men began to scheme in various ways, as they had never done before, to gain on those elements of friction which made the ways of life so difficult. At first the plan of keeping every valuable discovery secret served indifferently well all the needs of the inventor; generally the new process was of a nature to be protected in this way, but the public profited imperfectly from this way of dealing with the advances in discovery. To be successfully hidden, few must know the secret, and its results must bear the tax of danger as well as of skill. At this stage the king steps in, and as he, in those days, granted away lands of which he knew not even the boundaries, so he gave the seal of a legal right to the product of the brains of his subjects. Public opinion, crystallized in law, already protected the right of the possessor in the fagots by his fireside, which were cut from the common wood, or to the game which fell to his skill or hardihood. But for this new-found sort of property in far lands, found beyond difficult seas, or in the hard-won, untraveled paths of nature, there was needed a formal sign for sanctification, which was best found in Royal Letters Patent. Inasmuch, however, as these privileges of the king were usually granted for a limited time, and from the fact that such ancient monopolies as the making of salt, etc., were limited in their duration, the right to these creations of the subjects' brain was also limited. This limitation in time, though perhaps warranted by other considerations, seems to have been essentially due to the accidental associations of monopolies of invention with those other and usually limited monopolies in the king's gift.

Whoever will consider the circumstances connected with the origin of this sort of title to intellectual property, and compare it with those other property rights which are commonly considered the more real, will become convinced that the element of newness is the most noticeable feature concerning its history, and that in its origin it is essentially like the other property rights. If a man finds a stone and shapes it to his needs, he acquires a property therein. A later and more skilled man gets the solution of a harder problem from the dark recesses of natural possibilities; it is but an extension of the same principles of property to give him the full fruits of the labor he has given to his work. And it is the finest extension of the sense of property that has led to the affirming of this right in the laws of most nations.

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But it is not in the matter of absolute right alone that we can find the strongest defence of these intellectual monopolies. The position taken from the point of view of public policy is even more impregnable than it can be made on the side of the equities. If society has one interest which more than another should be held sacred, it is that element of eager foresightedness that keeps men exploring every dark place in the line of social advance for the means of good or the remedies of evil that may be found there. It is not too much to say that it is to these few larger souls that society owes its substantial gains, and that to the development of this spirit it must look for all future material advances on its difficult way. Whatever serves to increase this element in any society adds to the rate at which it gains on the difficulties which beset its advance; whatever retards the development of such a spirit is so much gain to the forms of inaction. The mass of men of any generation are born to an instinctive acceptance of things as they are; it is rare that men are awakened to a struggle with the evils of their environment. These changeful spirits are never found in some races; it is the great good fortune of our own to have developed this eagerness for striving against the darkness of the unknown. Whoever will trace the development of this spirit in this country and in England, the two regions where it has become most active, will be convinced that its activity is mainly due to the development of those faculties caused by their system of patent and copyright laws. Each country offers instances of rewards, given to mechanical skill, as brilliant in appearance as the marshal's baton which waved in the air before the recruits of the grand army. To gain these rewards is the incentive that leads thousands to that determined struggle, which in invention, as in all other contests, is the condition of great victories. For the one invention that has proved successful there have always been the thousands that are utter failures, giving no reward but fruitless expectations. . . . When we consider the reward that this labor receives, we shall find that it is on the whole less paid than in any department of public service. The few get the gains of princes; the mass receive poverty, intensified by the disappointment of great expectations. It is the few great prizes this life has to offer that enlists so many venturous spirits in its work. Whatever

should tend to take away the hope of almost fabulous wealth would remove this provocation to enthusiasm, and this form of human effort would become a thing of the past. This consideration should make an end of the various plans for limiting the rewards of invention; nothing but the millions that await the one triumphant inventor will lead the rest of the ten thousand to take the chances of failure that must await them. It would be infinitely better for society to let the fortune of the Rothschilds reward the success of some genius who should deserve it by an invention that laid every man under contribution than to take the inevitable reduction of the advance in the subjugation of the world to our needs which the destruction of the inventive spirit would entail. Any scheme that threatens to lower the value of the rewards of any form of intellectual life is directed against the dearest interests of society. In all the accustomed pursuits of intellect this would be readily acknowledged. No reasonable man would for a moment think of suggesting that the most eminent men at the bar, or the great physicians, or the successful clergymen, should be fined for their success to reward the mediocrities of other occupations, nor are there many who would think that the honors, wealth, and fame showered on a great general were bad investments for a State; it may not need a savior once in a thousand years, yet such monumental prizes as those won by Wellington or Marlborough are in a certain way schools of greatness, breeding in their time other Wellesleys and Churchills. We must come to recognize invention in all of its forms as a distinct class of human endeavor, one that cannot be spared from the standard labors of the world, entitled to its rewards, not only of honor, but of more substantial goods. We must see that whatever threatens to limit these in the case of inventors threatens the interests of society at least as much as if directed against the rewards of skill in medicine or statecraft.

With the proposition clearly before us that the advance of a community in the ways that lead to wealth is determined by the extent to which the inventive faculty is exercised among its people, the question arises, What can be done to extend its development through the institutions of an educational, a social, or a legislative nature? It is easier to suggest the need than it is to provide for its supply. The education of the elements of the imagination and judgment that is required in all inventive labor can only be secured by the practice of work requiring the activity of these qualities. Our schools are wanting in any extended system to supply these needs. Something can be done by giving young men the especial training in laboratory work which experience proves to be an admirable means of developing those powers; but, as our educational institutions now exist, it is idle to suppose that a large enough part of our population can make the advance in experimental science that would be required in order to have them profit by the training it can give. It seems that we must trust to the training that the shops themselves may give, aided by the stimulus of great prizes procurable by those who attain to excellence in their special pursuits; with a fortune awaiting his success in solving some small problem of improvement in the machines of his daily craft, with access to certain teaching as to the principles of machines in books or in schools of mechanic arts, we may trust the naturally gifted operative to find his way to his training—a training by no means perfect, but in a way suited to his needs. As far as we can give the foundation for an understanding of the elements of physics, dynamics, etc., in our intermediate and higher schools, it will be well; but we must trust to the training at the work itself, plus the stimulus of the prize, for most of the results we seek to obtain.

Fortunately there exists for us a practical experiment as to the relative value of training, and of the prize of large monetary gain in stimulating inventiveness. The republic of Switzerland, with the seemingly sagacious consideration that they might profit by using the inventions of their neighbors without paying an equivalent therefor, long ago resolved that they would grant no patents within its territory. It appeared at first a profitable piece of sharp dealing to reserve the power of using all inventions for which others were taxed quite without payment therefor. Yet despite the remarkably advantageous position of Switzerland, the natural vigor and capacity of her people, and their admirable system of public education, there have been disadvantages connected with this plundering system that give us another proof that, in the long run, honesty is the best policy. All the while that Switzerland has been trusting to outside training for every invention she has applied in her manufactories, she has failed to train her own people in inventiveness; the result is, that Switzerland, of all civilized countries, is the most backward in the adaptation of every skilful appliance in every part of her economic life. One of the results gives a most surprising evidence of the preponderance of training over all the other advantages of the world. Despite Switzerland's cheap labor, low taxes, low interest, and central position, Americans, carrying their burden of debt, costly labor, high taxes, dear money, and remote position, are surpassing them in arts which have been their own for centuries. American watches, as good as their best, are sold at their doors for less money than they can make them. Our well-developed mechanical imagination has so organized the labor and the machines used in this branch of manufacture, that the advantages derived therefrom outbalance the vast advantages of the Swiss labor. Our labor is double or more, our taxes double or more, our interest about double that of Switzerland, we have no traditional skill, nevertheless inventiveness conquers them all. Yet the inventiveness used in this work is but a very small part of our vast store of the priceless product of imaginative labor that has been created for us by our patent system. It is a work of generations to create such a training. It is questionable whether a State originating it at so late a date as Switzerland will have to do can ever overtake a country like this, where there is nearly a century of the stimulus in the blood of the people.

The experience of Switzerland shows plainly that it is not the untaxed use of the inventions that give the means of doing the difficult things in manufacture that is the great point gained by a system of patent law, for that country has had access to all such inventions at an even cheaper rate than other countries; it is rather the training that comes from the continued work of devising, the habit of meeting difficulties as they arise, the habit of never being content with the existing condition of any work while betterment is possible.

Again, it is argued that inventors are naturally impelled to do their work, and would do it all the same, whether they were paid or not; but paying for their labor is like paying for gravitation or air or a running stream. There is no doubt that the impulse to invention is in many cases innate; so is the impulse to the law, or to the practice of medicine or trade. But we don't make lawyers' or doctors' fees uncollectable, because we find that people rather like to give gratuitous counsel or physics to their neighbors, as we should if we really believed that the work we want them to do would be done as well without pay. It will be well, moreover, for these speculative minds to consider what an invention means; it means the turning of the ways of men from old channels to new, always a difficult task. Few inventions of value can be put into the complicated framework of society without years of devoted toil and vast sums of money. Take a new invention that will revolutionize trade; grant that, when introduced, it will save, say, five million days' labor each year to this country. It will then have to overcome the inertia of a vast machinery, and the opposition of a great population, who are monetarily troubled by it. Experience shows that it will require from ten thousand to half a million dollars to give this seed a chance to take root and show its nature. Where are the philanthropists who will give their time and money to this work, if their pay is to be made in fine words? Or what system of governmental aid is to determine the machines or processes that are to be tried at the public cost? The very energy of the advance of our modern civilization adds to the difficulty of introducing new features into its mechanism of thought or action. Now and then there are men of Archimedean genius, who bring such power to their work that they may succeed in making considerable revolutions by mere force of genius. Count Rumford and Benjamin Franklin, among our own countrymen, and near our own time, have shown a power to push novelties into general use, but both had the fame and place of political success to back their projects. Moreover, modern inventions are generally of a complicated nature, and demand far more continued labor in their projection and introduction than those of Franklin or Rumford. We have passed by the simple stage of our discoveries, when important changes can be made by the sporadic energy of great intellects finding their customary avocations in other fields. Men must now give their lives to the work of inventing, in case they are to attain any eminent success whatever, and their lives must be able and devoted, and as a condition thereto, must be well paid. When some other practicable means of payment is suggested, it will be full time for us to abandon the present system, which, with all its defects, certainly gives the necessary stimulus to insure the activity of the inventive faculties of our people.

It has been furthermore suggested that the ordinary stimulus of competition in trade would, of itself, lead to the employment of inventive mechanics on the part of great manufacturers, in order to get an advantage over their competitors. The experience of Switzerland should be a sufficient answer to this unlikely objection. Manufacturers there have not been found to do any such thing, although pressed thereto by great needs, and supplied with every element of liberal-mindedness and ambition. Men are never willing to make roads for others to travel; it has not been found that men built railways for the pure enterprise of the thing, and it is ridiculous to talk of manufacturers building costly ways to new methods, when others could traverse them without cost.

In case the present patent system were abolished, there would doubtless be a vigorous method made to utilize the profits which are to be made from certain sorts of inventions around which a net of secrecy can be drawn. We would have again the mediæval system of men surrounding their processes with mystery, which was often made eternal by their death. But many inventions—such as the Westinghouse air-brake, for instance—must be operated in the open day, if used at all, and for these there would be no means of protection.

Driven from his last position, our advocate of the new method of getting something for nothing out of men's brains will perhaps say, How is it that scientific men are doing such wonderful things? They do not patent them, but make their works solely for the love of us their greedy fellow-men. Here, too, the reckoning is made without the host. Scientific men are paid, and in their way pretty well paid for their work, although the pay is not in money; besides their subsistence, there is the prize of reputation and of station in their class, which will spur men to any labors. But, unhappily, the bettering of some economic engine does not draw any of these prizes. If our friends will engage to secure the organization of a society where the invention of the little devices that grow into great machines will secure the prizes won by Faraday and his peers, there will be a chance of dispensing with the money profit of inventions as a means of securing their production. But though we may imagine conditions of society where the invention of the thousand and one things that make up the whole of great machines should be rewarded by laurels, our present world pays them with money rather than praise, and is certain to pay in no rarer thing for a great while to come.

Brontidi, Mistpoeffers, or Barisal Guns

By Charles Fitzhugh Talman

THERE are two phenomena of nature, both mysterious and unexplained, the reality of which, though sometimes doubted, seems to be attested by the fact that in each case we find the same facts reported from widely scattered communities under a great variety of independently-formed names. One of these is the will-o'-the-wisp, which bears at least twoscore names in the English language alone, and probably as many in German. The diversity of nomenclature is evidence of independent observation of the phenomenon in question; for if any given community had merely borrowed its ideas on the subject from its neighbors, it would have borrowed the name as well.

The name *brontidi*[1] (i. e., "like thunder") was coined in 1904 by Prof. Tito Alippi in order to facilitate the discussion of a phenomenon known under a bewildering variety of local names in various parts of Italy—*marina, bomba, rombo, boato, bonnito, mugghio, baturlio, tromba, rufa*, etc. Forty of these names are enumerated in one of Alippi's memoirs, and he has furnished several additions to the list in subsequent publications. Brontidi are usually described as detonations resembling distant and muffled discharges of cannon or peals of thunder, sometimes heard singly and sometimes in groups. They occur chiefly in warm and settled weather, when the air is calm and the sky clear. Their distribution over the Italian peninsula has been carefully studied and mapped; it appears that while they are common in some localities, they are quite unknown in others not far distant. The peasantry have various explanations for them—natural and supernatural—but the unanimous opinion, which has been fully confirmed by scientific investigation, excludes the possibility that they are due to any human agency or to thunder. The most curious feature of the phenomenon is that the detonation always appears to come from a distant source.

The same phenomenon is well known on the coast of Belgium under the name of *mistpoeffers* (i. e., "fog-belchings," "fog-hiccups"); also as *zeepoeffers, mistbommen, paper-bags, rots de mer, bombes de mer, canon de mer*, etc. Here they were made the subject of painstaking investigations by E. van den Broeck, beginning about 1890, and it was found that they occurred not only on the coast but in the interior of Belgium and adjacent countries.

[1] This seems likely to become the international name of the phenomenon, either with or without modifications in termination to adapt it to the various languages. It was Anglicized to "brontides" by a writer in *Nature*, November 30th 1911, p. 154. It would also become "brontides" in French, "Brontiden" in German, etc.

Phenomena of this class were, however, first systematically studied in India. At a meeting of the Asiatic Society of Bengal in May, 1867, Babu Gaurdas Bysack called attention to the mysterious sounds, resembling distant cannonading, frequently heard throughout the Ganges delta. His remarks called forth numerous communications, published in the newspapers and scientific journals of India, showing that these detonations were familiar in many localities. From the circumstance that the phenomenon is observed with great frequency and intensity in the neighborhood of Barisal—a town on a delta-island of the Ganges, about 120 miles from Calcutta—we have the name "Barisal guns," under which these mysterious sounds were made known to European science at a meeting of the British Association in 1890. Numerous observations of the phenomenon had been collected the preceding year by a special committee of the Asiatic Society of Bengal. The report of the committee discussed various suggested explanations, without coming to any conclusion.

Thus, systematic investigations of brontidi (to adopt Alippi's non-committal name of the phenomenon) have been made in three widely scattered countries—Italy, Belgium, and India. Recently a similar undertaking has been carried out by Dr. J. D. Cleland in Australia, where the phenomenon has been known for years under the name of "the desert sound." The publication of these studies has had two results; first, it has led to a search of earlier literature for references to similar phenomena, and it is found that these are rather numerous; and second, it has called forth reports of the contemporary occurrence of brontidi in many other parts of the world.

Thus, Van den Broeck quotes a reference in the works of Lord Bacon to "an extraordinary noise in the sky when there is no thunder." Similar phenomena are mentioned by Humboldt and Boussingault. In some of the early reports the detonations are described as occurring in connection with earthquakes, but also when there were no sensible shocks of this character. Unmistakably subterranean noises, with or without earthquakes, should perhaps not be included in the same category with brontidi, the source of which—whether in earth or air—is not obvious to the senses. Such noises are mentioned by Aristotle and Pliny, and a remarkable case is reported in Humboldt's "Cosmos," as having occurred in Mexico in 1784; for a whole month the town of Guanaxuato was kept in terror by a succession of subterranean *bramidos* ("roarings"), unaccompanied by any trace of an earthquake. A typical occurrence of brontidi is recorded in Capt. Sturt's "Two Expeditions into the Interior of Southern Australia" (2d. ed., 1834, vol. I, p. 98) as follows:

"About 3 P. M. on the 7th (i. e., February 7th, 1829) Mr. Hume and I were occupied tracing the chart upon the ground. The day had been remarkably fine, not a cloud was there in the heavens, nor a breath of air to be felt. On a sudden we heard what seemed to be the report of a gun fired at the distance of between five and six miles. It was not the hollow sound of an earthly explosion, or the sharp cracking noise of falling timber, but in every way resembled a discharge of a heavy piece of ordnance. On this all were agreed, but no one was certain whence the sound proceeded. Both Mr. Hume and myself had been too attentive to our occupation to form satisfactory opinion, but we thought it came from the northwest. I sent one of the men immediately up a tree, but he could observe nothing unusual. The country around him appeared to be equally flat on all sides, and to be thickly wooded. Whatever occasioned the report, it made a strong impression on all of us; and to this day the singularity of such a sound in such a situation is a matter of mystery to me."

Nowadays every year brings fresh reports of the occurrence of brontidi in widely scattered parts of the world. On the shores of Lough Neagh, in Ireland, mysterious sounds as of gunshots, generally heard in fine weather, have long been known as "water-guns." According to Prof. Scherer, of the College St. Martial, Port au Prince, brontidi have been frequently heard in Haiti, where the phenomenon is known as "gouffre." From time to time similar phenomena have been reported in the United States. It is said that they occur at Moodus, Conn., where they are known as "Moodus noises."

In its issue of October 19th, 1907, the Scientific American published a brief notice of one of Prof. Alippi's memoirs on brontidi. A result of this notice was that the Italian savant received an interesting letter from a correspondent in California reporting the frequent occurrence of brontidi in his neighborhood, viz., in Marin, Sonoma and Mendocino counties, apparently along a fault-line extending inward from the coast This writer, Mr. George Madeira, also published an article on the subject in the Santa Rosa *Republican*, in which he states that brontidi are often heard during the warm summer months in the middle and west coast mountains of the State; also sometimes on winter nights. He goes on to say that "a tremendous explosion, presumably in the air, occurred in September, 1896, near Cazadero, heard by the dwellers of the mountain region over an area of 900 square miles."

Although so great a number of observations of brontidi have been reported, it is reasonably certain that the unreported cases are far more numerous. Probably as a rule a person who hears one of these detonations pays little attention to it, assuming that it is actually what it appears to be, viz., the report of a distant cannon, an explosion of dynamite in blasting operations, a peal of thunder, or whatnot. It is only when the phenomenon occurs in a place remote from human habitation, and when the observer takes note of the fact that the meteorological conditions make the proximity of a thunderstorm extremely improbable, that the noise compels attention as something out of the ordinary—assuming that the observer has no knowledge of brontidi, as such. On the other hand, persons who make regular observations of brontidi for the benefit of science probably often record other sounds under this designation. Thus it has been noticed that the keepers of lighthouses and lighships on the North Sea coast, who keep records of brontidi for the meteorological service of Belgium, report these phenomena much less frequently on Saturdays and Sundays than on other days of the week; a fact that seems to indicate that many of the supposed brontidi of that region are due to human agencies.

Occasional cases of malobservation, however, do not affect the problem as a whole. Evidence of the existence of brontidi as a phenomenon of nature is overwhelming, and the explanation of these curious noises is an inviting task for the scientific man.

Many suggested explanations that seemed more or less plausible when the problem was viewed as a local one—as in the early discussions of Barisal guns—are invalidated by the wide range of physical conditions under which the phenomenon is now known to occur, and need not be enumerated here. The trend of recent opinion is toward looking upon the source of brontidi as subterranean in most cases, though perhaps not in all. Movements within the crust of the earth must frequently set up vibrations of such an amplitude as to affect the ear, when communicated to the overlying atmosphere; and as rocks are generally excellent conductors of sound (i. e., of vibrations within the range of audibility) the effects may be transmitted to great distances from their source. Assuming the focus to be far below the surface, the air would be set in vibration over a wide area, giving the indefiniteness as to the direction of the sound that is commonly noted. Prof. W. H. Hobbs, who has made a painstaking study of the seismic geology of Italy, concludes that the brontidi of that country are due to the slow settlement of orographic blocks, and the consequent production of vibration within their marginal zone. Utilizing the reports collected by Alippi, he shows that the places where brontidi occur are also places that are subject to frequent earthquakes; they are arranged in lines which he identifies with seismotectonic lines, and they follow geological contacts and other earth lineaments. In other words, they are fault lines of structure lines of the earth, whose presence is revealed by earthquakes and also by brontidi. He has called attention to the great importance of studying these phenomena with the aid of microphones, in order to locate the lines more accurately, as a contribution to the seismological survey of the country According to this writer there is no sharp distinction between brontidi and the sounds that actually accompany earthquakes. Prof. Alippi, who has probably made a more thorough study of the phenomenon *in situ* than any other living person, while accepting without hesitation the subterranean origin of many or most brontidi, is not convinced that they may not also sometimes be of atmospheric origin. He can, however, offer no explanation of atmospheric brontidi, if they exist.

The initial cause of brontidi—whether in or out of the earth—is only half the problem. They must also be studied as an interesting acoustic phenomenon of the atmosphere As we have stated, they occur when the air is tranquil—hence homogeneous horizontally—though, as they seem to be most common on warm afternoons, they may be in some way conditioned by strong inversions of temperature, and hence of density, in the vertical. Lastly, it seems probable that, as Alippi believes, the initial vibrations, whatever their cause, are far more common than audible brontidi. In order that the sounds may be heard they must be re-enforced by a peculiar configuration of the ground, above or below the surface; where such conditions exist brontidi are observed, while where they are lacking the vibrations pass unnoticed. Alippi attaches special importance to the effect of caverns, which he suggests act as resonance boxes in the production of audible brontidi.

Aluminium Alloys

In the Engineering Section of the British Association meeting at Dundee, Ernest Wilson presented a report on "Exposure Tests of Light Aluminium Alloys." Investigations made during the last ten years have shown that alloys of commercial aluminium with copper only were not satisfactory. Wilson investigated alloys in the form of wire, 0.126 inch in diameter, to ascertain the effect of exposure on electrical conductivity. The addition of iron, nickel and manganese to the low-copper alloys was found to increase both the tensile strength and the resistance to deterioration. With specimens containing, respectively, 1.16 per cent of iron, 2.25 per cent of nickel, and 1.78 per cent of manganese, the electrical resistance had only increased about 9 per cent in eleven years. "Duralumin" was a copper-manganese-aluminium alloy, plus about 0.5 per cent of mangnesium, and after an exposure of one year a specimen 80 feet long had increased 5.15 per cent in electrical resistance. Wilson asked, was this due to the comparatively high percentage of copper or was the manganese too low? This alloy could, by suitable treatment, be obtained with a very high breaking load, but its specific resistance was about twice that of commercial aluminium.

In the discussion, Lupton pointed out the well known destructive action of salt on aluminium and its alloys. Petavel called attention to the fact that "duralumin" at its best might have the lightness of aluminium with the strength of steel, but, unfortunately, it was extremely sensitive to heat treatment.

In this connection, see W. Roberts-Austen, Third Report of the Alloys Research Committee, wherein the melting points of the iron-aluminium alloys are given; and E. F. Law, Faraday Society, June, 1910.

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